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The Engineer

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PUBLIC NOTICES

Royal Corps of Naval Constructors.

A COMPETITIVE EXAMINATION for a POST as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, during the first fortnight in July next.

Candidates must not be more than 24 years of age on 1st October next, and must then have been engaged in practical shipbuilding work for at least 18 months. Graduates from the Universities are preferred.

The salaries and other conditions of service are given in full in the regulations of the Royal Corps of Naval Constructors. The salaries during the two or three years' Greenwich course, including cost-of-living bonus reckoned at its present rate of 70, are approximately as follows :—

Probationary Assistant Constructors on joining R.N. College, £190 in addition to mess allowance.
Probationary Assistant Constructors during second half of course, £220 in addition to mess allowance.

Candidates successful at the end of the R.N. College Course will be admitted into the Royal Corps of Naval Constructors as permanent Civil Servants, with corresponding superannuation and other privileges ; the salaries, including bonus as above, of the lower grades being approximately as follows :—

2nd Class Assistant Constructor (first 3 years), £320-£360.
1st Class Assistant Constructor (after 3 years), £430, rising to £710.

The salaries, &c., for the higher grades are stated in the regulations, which may be obtained from the SECRETARY OF THE ADMIRALTY (C.E. Branch), Whitehall, S.W.1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than Monday, the 26th instant.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

A QUALIFYING EXAMINATION will be held in conjunction with the above, for the admission to the Royal Naval College, Greenwich, of PRIVATE STUDENTS of NAVAL ARCHITECTURE who desire to receive instruction in the course laid down for PROBATIONARY ASSISTANT CONSTRUCTOR.

Applications for admission as Private Students should reach the SECRETARY OF THE ADMIRALTY (C.E. Branch) not later than the 26th instant.

Private students are required to pay a fee of £50 per session.

Applications for the regulations should be accompanied by an addressed foolscap envelope. 4960

The Government of India INVITE APPLICATIONS FROM STATUTORY NATIVES OF INDIA FOR AN APPOINTMENT OF ASSISTANT ENGINEER (INSPECTION WAGON) IN THE INDIAN STORES DEPARTMENT, for Steel Rolling Stock Inspection Work.

QUALIFICATIONS AND CONDITIONS.—Should possess an Engineering Degree qualifying for exemption from examination for the A.M. Inst. C.E. or the A.M.I. Mech. E., or have passed examination for Associate Membership of Institution of Civil Engineers or of Institution of Mechanical Engineers, or of the Institution of Engineers (India). A full apprenticeship or pupilage with firm of steel railway wagon builders or in railway workshops, and drawing-office experience. Special experience of the construction of steel railway wagons and knowledge of theory and design of steel rolling stock. Age 24-35 years. Pay Rs. 500, rising by annual increments of Rs. 50 to Rs. 750 a calendar month and certain allowances. Provident Fund. Strict medical examination.

Further particulars and forms of application may be obtained (upon request by postcard) from the SECRETARY TO THE HIGH COMMISSIONER FOR INDIA, General Department, India House, Aldwych, London, W.C. 2. Last date for the receipt of applications 24th May, 1930. 4989

City of Cardiff Education Committee.
THE TECHNICAL COLLEGE.

Principal : CHARLES COLES, B.Sc. (Lond.).

The SERVICES will be REQUIRED in September next of a FULL-TIME ASSISTANT LECTURER in ENGINEERING qualified to teach up to Honours B.Sc. Standard. The main subjects required will be those of Mechanical Engineering and Civil Engineering, but a good knowledge of Electrical Engineering will be a recommendation.

Salary payable according to the Burnham Award.

Applications, on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, should reach the Principal (from whom further particulars may be obtained) on or before Saturday, 17th May.

The successful candidate will be required to pass a medical examination by the Authority's Medical Examiner for Teachers at Cardiff before commencing duties, and to contribute under the Teachers' (Superannuation) Act, 1925.

HARRY H. THORBURN,
Acting Secretary for Education.
City Hall, Cardiff. 4913

The Worshipful Company of Armourers and Brasiers in the City of London.
RESEARCH FELLOWSHIP IN AERONAUTICS.

The Armourers' and Brasiers' Company are offering a FELLOWSHIP of £300 per annum, for two years, for Research in Aeronautics.

Applications must be sent before the 31st May, 1930, to the CLERK, Armourers' Hall, 81, Coleman-street, London, E.C. 2, from whom forms of application and particulars of the Fellowship can be obtained. 4944

Witwatersrand Technical College,
JOHANNESBURG, SOUTH AFRICA.

APPLICATIONS are INVITED for the POST of LECTURER-IN-CHARGE at an important Branch of the College near Johannesburg. A regular training in engineering, including workshop practice, is essential. Applicants must also be graduates or possess equivalent qualifications. Personality, organising ability and initiative and previous lecturing experience will be recommendations.

Salary scale : £450-25-£650 plus local allowance. Local allowances : in the case of a married officer, £66 to £76 ; single officer, half these amounts. The appointment is full time and includes both day and evening work. An allowance of £60 will be made towards travelling expenses, with half salary from date of sailing to date of arrival in Johannesburg.

The initial salary may be fixed according to existing salary, qualifications and experience of the successful applicant, who will be required to join the Government Provident Fund.

Applications in duplicate, giving full particulars of training and experience, must be submitted on or before the 31st May, 1930, to Messrs. CHALMERS and GUTHRIE (MERCHANTS), Ltd., 9, Idol-lane, London, E.C. 3, from whom conditions of service and special application forms may be obtained. 4977

PUBLIC NOTICES

Administrative County of London.
ROBERT BLAIR FELLOWSHIPS IN APPLIED SCIENCE AND TECHNOLOGY.

APPLICATIONS are INVITED for the AWARD of TWO ROBERT BLAIR FELLOWSHIPS in APPLIED SCIENCE and TECHNOLOGY, each of the value of £450, tenable for one year. The Fellowships are for advance study or research in applied science and technology, and will be tenable in the Dominions, the United States or other foreign countries.

Candidates must be British subjects and at least twenty-one years of age.

Further particulars and application forms (T3) may be obtained from the EDUCATION OFFICER (T. 3), The County Hall, S.E. 1 (stamped addressed envelope necessary), to whom the form must be returned by 18th June, 1930.

MONTAGU H. COX,
4836 Clerk of the London County Council.

University College of Swansea.

The Council invites APPLICATIONS for the POST of ASSISTANT LECTURER in the Department of Metallurgy. Salary £300 per annum. The appointment will date from the 1st September, 1930.

Further particulars may be obtained from the undersigned, by whom applications must be received on or before the 28th May, 1930.

EDWIN DREW,
Registrar.
Singleton Park, Swansea. 4962

Bengal-Nagpur Railway Company, Limited.

The Directors are prepared to receive TENDERS for :—

(a) 2800 LAMINATED BEARING SPRINGS.
(b) 7600 VOLUTE SPRINGS.
(c) 700 STEEL C. and W. TYRES.
(d) 400 WHEELS, 3ft. 1in. dia. on tread.

Specifications and forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad-street, London, E.C. 2, on or after Tuesday, 6th May, 1930.

A fee of 10s. will be charged for each copy of the specification, which is not returnable.

Tenders must be submitted not later than Noon on Friday, 16th May, 1930.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board,
R. GRANT,
4942 Secretary.

PUBLIC NOTICES

Bombay, Baroda and Central India Railway Co.

The Directors are prepared to receive up to Noon on Friday, 30th May, TENDERS for the SUPPLY of :—

1. CHEMICALLY DRESSED WAGON COVERS.
2. WOOD SCREWS, SPLIT PINS, &c.
3. WROUGHT IRON or MILD STEEL PIPING, &c.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.
Offices : The White Mansion,
91, Petty France, Westminster, S.W. 1,
6th May, 1930. 4986

Borough of Richmond (Surrey).
WATERWORKS DEPARTMENT.
TENDERS FOR COVERED SERVICE RESERVOIR, PUMPING STATION, and CAST IRON MAINS, &c. TO CONTRACTORS.

The Corporation invite TENDERS for the following WORKS :—

CONTRACT No. 8.—The Supply of approximately 380 Tons of Cast Iron Pipes and Special Castings.
CONTRACT No. 9.—The Supply of Sluice Valves and Air Valves.
CONTRACT No. 10.—The Laying and Jointing of approximately 870 Yards of 14in., 1250 Yards of 12in., 1490 Yards of 9in. Mains, and 67 Yards of 12in. River Water Intake Pipe.
CONTRACT No. 11.—The Construction of a Covered Service Reservoir having mass concrete walls and floor, and reinforced concrete roof, Covering of an existing Reservoir with a Reinforced Concrete Roof, and the Erection of a Pumping Station Building, &c.

Drawings may be seen and copies of the general conditions of contract, specifications, bills of quantities and forms of Tenders for each of the contracts may be obtained from Mr. H. P. Williamson, M.C., M. Inst. C.E., Water Engineer and Manager, Hotham House, Heron Court, Richmond, Surrey, on deposit of a crossed cheque for £3 3s. for each contract, which will be returned on receipt of a bona fide Tender.

Sealed Tenders, should be delivered to the undersigned not later than 10 a.m. on Thursday, the 22nd day of May, 1930.

The Corporation do not bind themselves to accept the lowest or any Tender.

EDWIN M. NEAVE,
Town Clerk.
Town Hall, Richmond, Surrey,
May, 1930. 4945

PUBLIC NOTICES

City and Royal Burgh of Dundee.
ELECTRICITY DEPARTMENT.

The Corporation invites TENDERS for the SUPPLY and LAYING of approximately 655 FEET of 42in. diameter CAST IRON, SPIGOT and FAUCET PIPING. The excavation work and the construction of the foundation for the pipes will be executed under another contract.

Specification, schedule of quantities, form of Tender and general conditions of contract and drawings may be obtained from the undersigned on payment of a deposit of £2 2s., which sum will be returned upon receipt of a bona fide Tender.

Tenders (sealed in envelopes provided) must be lodged with W. H. Blyth Martin, Esq., Town Clerk, City Chambers, Dundee, not later than by Saturday, 14th June, 1930.

The Corporation does not bind itself to accept the lowest or any Tender.

D. H. BISHOP, B.Sc., M.I.E.E.,
General Manager and Engineer.
Electricity Supply Department,
Dudhope Crescent-road, Dundee,
2nd May, 1930. 4949

County Borough of Halifax.
HALIFAX CORPORATION WATERWORKS.
WARLEY MOOR RESERVOIR.

The Waterworks Committee are prepared to receive TENDERS for the RECONDITIONING of WARLEY MOOR or "FLY FLAT" RESERVOIR, situate at the head of Luddenden Brook, about 6½ miles from Halifax. The work will consist of the construction of an embankment across the northern end of the reservoir, the removal of peat from the bottom of the reservoir, and its disposal behind the said embankment, the lining of an existing catchwater, and the construction of an entrance road, &c.

Drawings may be seen and copies of the specification, schedule and form of Tender obtained on application to Messrs. G. H. Hill and Sons (Manchester), Civil Engineers, 40, Kennedy-street, Manchester, upon the receipt of a cheque for Five Guineas. This sum will, after the Corporation shall have come to a decision upon the Tenders, be returned to those parties who shall have sent in a bona fide Tender, shall not have withdrawn the same, and shall have returned the documents and drawings lent to them for the purpose of making up their Tender. A limited number of sets of drawings (uncoloured) are available and will be lent to persons tendering in priority of application on receipt of the sum of Two Guineas, which will not be returned.

Sealed Tenders, endorsed "Halifax Corporation Waterworks, Warley Moor Reservoir," must be forwarded to the Town Clerk, Town Hall, Halifax, on or before Friday, the 16th May, 1930.

The Committee do not bind themselves to accept the lowest or any Tender.

PERCY SAUNDERS,
Town Clerk.
Town Hall, Halifax,
12th April, 1930. 4967

Egyptian Government.

TENDERS are called for by the Mechanical Department, Ministry of Public Works, for the SUPPLY and ERECTION in the Isolated Basins, Aswan Province, of FIFTEEN ELECTRIC PUMPING STATIONS, complete with all the necessary BUILDING WORK, PUMPS, MOTORS, SWITCHGEARS, and PUMP HOUSES, &c.

Tenders should be submitted direct to the DIRECTOR-GENERAL, Mechanical and Electrical Department, Ministry of Public Works, Cairo, not later than Noon on the 17th August, 1930.

Copies of the necessary conditions of Tender, specifications and drawing, &c., can be obtained on application to the Chief Inspecting Engineer, Egyptian Government, 41, Tothill-street, S.W.1, against the remittance of £10 5s. per set, which sum is not returnable. Copies of these documents are also available for scrutiny at the above address.

Firms on the Continent should apply to the Egyptian Consulate in their respective countries for the above-mentioned documents. 4947

Portadown Urban District Council.
SEWAGE PUMPING MACHINERY.—CONTRACT NO. 3.

The above Council invite TENDERS for the SUPPLY, ERECTION and FIXING of EIGHT SETS of ELECTRIC MOTORS and CENTRIFUGAL PUMPS with AUTOMATIC SWITCHGEARS at the three Pumping Stations in Portadown.

Specification, schedule of prices and form of Tender may be obtained on application to the Engineers, Messrs. Taylor and Wallin, 1, Saville-place, Newcastle-upon-Tyne, on payment of £10 deposit, which sum will be returned on receipt of a bona fide Tender and of the documents lent to the contractor for the purpose of preparing his Tender.

Sealed Tenders, endorsed "Pumping Machinery," on the prescribed form, with the schedule of prices properly filled in, must be delivered to me, the undersigned, at my office not later than 31st May, 1930.

The machinery is to raise UNSCREENED sewage, containing rags, cloths, string, rope ends, &c. &c., brought down in the sewers : ordinary centrifugal pumps for clean water are quite unsuitable, of no use for this work, and will not be considered.

The machinery will be let in ONE contract and will not be separated.

The Council do not bind themselves to accept the lowest or any Tender.

(Signed) HERBERT SEWELL,
Town Clerk.
Town Hall, Portadown,
May, 1930. 4981

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PUBLIC NOTICES

South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

1. COPPER RODS and TUBES and BRASS SHEETS, &c., and
2. ELECTRIC CABLES and WIRES.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Copper Rods and Tubes and Brass Sheets, &c.," or as the case may be, with the name of the firm tendering, must be left with the undersigned not later than Twelve Noon on Friday, the 23rd May, 1930.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specification No. 1, and of 5s. for each copy of Specification No. 2.

A. MUIRHEAD,
Managing Director.

91, Petty France, Westminster, S.W. 1.
7th May, 1930. 4987

City of Nottingham.

WATER DEPARTMENT.
ENGINEERING ASSISTANT.

The Water Committee REQUIRE the SERVICES of an ENGINEERING ASSISTANT, not exceeding 35 years of age.

Candidates must be qualified engineers, good draughtsmen and surveyors. Previous experience in a Waterworks Engineer's office is essential.

The salary will be in accordance with Grade C (Professional) of the City Council's Grading Scheme—gross £375, net £320 17s.

The appointment will be subject to the provisions of the Local Government and Other Officers' Superannuation Act, 1922, and the successful candidate will be required to pass a medical examination.

Forms of application may be obtained from Mr. F. W. Davies, Engineer and General Manager, Castle Waterworks, Castle Boulevard, Nottingham.

Applications, in candidates' own handwriting, should be accompanied by copies of three recent testimonials and delivered to me not later than Twelve o'clock Noon on Monday, the 26th May, 1930.

W. J. BOARD,
Town Clerk.

Guildhall, Nottingham,
28th April, 1930. 4904

Civil Engineering Draughtsman WANTED by the SOUTH STAFFORDSHIRE WATERWORKS COMPANY. Age 25-30. Experienced in waterworks design and general draughtsmanship of a waterworks Engineer's office. Commencing salary £250 per annum, which is subject to deductions under the Superannuation Fund.

Applications should give full particulars and be accompanied by copies of recent testimonials.

FRED. J. DIXON, M. Inst. C.E.,
Engineer-in-Chief.

28A, Paradise-street, Birmingham. 4978

Clerk of Works Required for Road and Sewer Construction Work on the Becontree Housing Estate, near Barking. Wages £6 6s. a week.

Apply, stating age, trade, and experience, to ADMINISTRATOR, Room 44, London County Council, Old County Hall, Spring-gardens, S.W. 1. 4956

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, TRAVELLER for Firm of General Engineers, to work Leicestershire; must have practical experience.—Address, stating age, qualifications, and salary required, P6980, The Engineer Office. P6980 A

ANALYTICAL CHEMIST WANTED, with Knowledge of Aluminium Alloy Analysis, to control routine testing. Excellent prospects and experience to be gained.—Address, stating qualifications and salary required, 4988, The Engineer Office. 4988 A

ASSISTANT MANAGER, Experienced Modern methods Ironfoundry, Machining, Jigs, Works Organisation, for General Engineering Works in South Country, employing 80 hands.—Address, P6990, The Engineer Office. P6990 A

CHIEF TESTER for Diesel Engines (Air Blast and Solid Injection) WANTED AT ONCE. Preference will be given to a technically trained man, 30-40 years of age, with sea-going experience.—Address in confidence, stating age, fullest possible details of past experience and positions held and salary required, 4899, The Engineer Office. 4899 A

ELECTRICIAN WANTED for a Jute Mill near Calcutta, capable of taking entire charge of Motors, Motor Generators, Transformers, Lighting, &c., in all about 4000 H.P.

Age about 30. Commencing salary Rs. 400, with commission minimum Rs. 150 per month, with free unfurnished quarters. Second-class passage out and home. Agreement 4 years. Strict medical examination.

Write, D.M., c/o Pottle and Son, 15, Cullum-street, E.C. 3. P6971 A

ENGINEER, with Experience in Design and Construction of Heavy Machinery for Hot Working Iron and Steel Materials. Rolling, pressing, punching, drawing and extrusion operations involved. A general metallurgical knowledge and practical experience of the behaviour of steel under all stress and heat conditions is essential. Position offers good prospects and agreeable conditions with well-established company for man of ability, energy and enterprise. Age and diplomas of secondary importance. First importance placed upon character and ability.—Address, 4963, The Engineer Office. 4963 A

ENGINEERING ASSISTANT (Temporary) REQUIRED for London. He should have experience in the design and construction of Sewers, Drainage Work and General Civil Engineering. Salary according to experience, but not exceeding £8 a week. Also a TRACER (Male, Temporary), with experience in a Civil Engineer's Office. Salary not exceeding 65s. a week.—Write, stating age, experience, &c., to Box 171, c/o E. Anderson and Co., 14, King William-street, W.C. 2. 4976 A

ENGINEER.—Old-established FIRM REQUIRES FIRST-CLASS MAN to Take Charge of Engineering Shops engaged in manufacturing specialised products to which developments in aviation provide important additional outlet.

Thorough training, preferably in Mechanical Engineering Practice, both design and production, and administrative experience essential. Age 35-40.

A substantial salary is contemplated, together with a bonus on results.

Address, P6976, The Engineer Office. P6976 A

HARBOUR ENGINEER.

WANTED, ENGINEER, age about 40, able construct Reinforced Concrete Jetties and maintain Works, Plant and Equipment for Small Harbour in Tropics. Must have had similar experience and accustomed under-water inspections.

Knowledge Spanish and good medical record essential. Progressive position. Send full particulars training, experience, salary required, and copies testimonials.—Address, P6989, The Engineer Office. P6989 A

KEEN YOUNG MEN, Age 22-25, of Good Education, with experience Oil Engines, for employment on agreement terms in India. Reply, stating age, education, experience, CLARKE and CO., Eastern Appointment Specialists, 3, Grosvenor-gardens, S.W. 1. P7001 A

SERVICES REQUIRED of ENGINEERING TRAVELLER having connection with Cement Works, Collieries and Contractors, Kent, Essex, Surrey, Middlesex. State age, experience, remuneration.—Address, 4957, The Engineer Office. 4957 A

LEASE OF IMPOSING OFFICES FOR SALE.
33, NORFOLK STREET, STRAND, W.C. 2.

In consequence of the recent amalgamation of "THE ENGINEER" LTD., proprietors of "The Engineer," with MORGAN BROS. (PUBLISHERS) LTD., proprietors of "The Ironmonger" and "The Chemist & Druggist," the offices of the three journals will shortly be transferred to new and more commodious freehold premises which have been acquired at 28-31, Essex Street, Strand, W.C. 2.

The remainder of the lease, covering a further twenty-five years, of the present offices of "The Engineer" at 33, Norfolk Street, Strand, W.C. 2, is in consequence for sale. This particularly well lighted five-storey building has an area of 8,200 sq. ft., and occupies a site at the corner of Norfolk and Howard Streets, adjacent to the Temple Station, whence Westminster and the City may be reached in a few minutes. The building is of modern construction and has a fine and distinctive elevation. It is in good order throughout, and vacant possession can be had in June next. Rent £1,600. Moderate price. For further particulars apply to:—

WHATLEY, HILL & CO.,
24, Ryder Street, St. James', S.W. 1.

SITUATIONS OPEN (continued)

TECHNICAL SALES REPRESENTATIVES REQUIRED throughout Great Britain, with live connection amongst steam users. Excellent prospects offered to really capable sales engineers.—Box 314, W. H. Smith and Son, Ltd., Strand House, London, W.C. 2. P6973 A

TRAVELLER, with Some Engineering Knowledge, to Represent a Firm of Agricultural and General Engineers in Midlands. Age, experience and salary required to be stated. Copy testimonials and photograph essential.
Address, P6983, The Engineer Office. P6983 A

YOUNG MAN, as ASSISTANT MANAGER and CHIEF ENGINEER for large Brickworks in South of England, using all types of modern power and machinery. Practical mechanical experience essential.—Address, 4990, The Engineer Office. 4990 A

WANTED, a DRAUGHTSMAN for London Office of Engineering Firm, preferably with experience of Pipe Work and some mathematical ability.—Address, stating age, salary, and experience, 4923, The Engineer Office. 4923 A

WANTED, DRAUGHTSMAN, Used Contractors' Plant, Concrete Mixers, &c. Give full details experience, names of employers, age, salary, when free.—Address, P6984, The Engineer Office. P6984 A

WANTED, for Cement Machinery Manufacturers, experienced Mechanical Engineering DRAUGHTSMEN. Experience in Cement Machinery and Plant an advantage, but not essential.—Write, giving age, salary and experience, to "CEMENT," Wm. Porteous and Co., Advertising Agents, Glasgow. P6983 A

WANTED IMMEDIATELY, First-class DRAUGHTSMEN, with experience in High-class Boiler Work and Power Plants.—Address, 4946, The Engineer Office. 4946 A

WANTED for North of England, LEADING DRAUGHTSMAN, accustomed to High-speed Four-cycle Diesel Engines.—Address, stating salary required, 4961, The Engineer Office. 4961 A

CHIEF DRAUGHTSMAN, Age About 35, WANTED for small D.O. in North of England. One with experience in Steel Wagon, Colliery, Plating and Light Railway Work on mass production lines preferred. State fully age, experience, and salary required.—Address, P6998, The Engineer Office. P6998 A

DRAUGHTSMAN.—Experienced DESIGNER REQUIRED, accustomed to Motor Road Rollers. Applications to state experience, age, and salary required.—Address, 4953, The Engineer Office. 4953 A

DRAUGHTSMAN, Experienced in Making Schemes of Conveyors and Mechanical Handling Plants for coal and other materials, REQUIRED in London. Only experienced men need apply. State age, experience, and salary.—Address, 4979, The Engineer Office. 4979 A

DRAUGHTSMAN, London, Experienced in Design and Details of Plate and Steel Constructional Work, also Pipe Arrangements and Condenser Details. State age, experience, including shop work and salary.
Address, P6974, The Engineer Office. P6974 A

DRAUGHTSMEN REQUIRED IMMEDIATELY. Must be accustomed to Modern Automobile Plant Lay-out and Installation; also have some experience in Light Steel Structures and Pipework. State age and qualifications.
Address, 4929, The Engineer Office. 4929 A

DRAUGHTSMAN REQUIRED IMMEDIATELY, London. Must be used to Furnace Design and Gas Producer Work. Excellent prospects for right man. State age, experience, and salary required.—Address, 4964, The Engineer Office. 4964 A

DRAUGHTSMEN REQUIRED in the Newcastle-on-Tyne district, having sound working knowledge of Materials Handling Plant. Must have experience in detail and design of modern plants. State salary and give details of experience.—Address, 4950, The Engineer Office. 4950 A

DRAUGHTSMEN WANTED, Fully Experienced Jig and Press Tool Designers. Must have first-class experience of Jigs, Press Tools and Production Equipment for Automobile Work. State age and experience.—Address, 4982, The Engineer Office. 4982 A

DRAUGHTSMAN REQUIRED, with First-class experience of Riveted and Welded Pressure Vessels, Tanks, &c. Must have good knowledge of estimating. Good prospects and permanency to capable man. State age, experience, salary, and when at liberty.—BRITISH APPLIANCES MFG. CO., Ltd., Dolly-lane, Leeds. 4984 A

DRAUGHTSMAN WANTED, Junior, Preferably with experience in Tanks, Pressure Vessels and Structural Work.—State age, experience, salary, and when at liberty, by letter, to ROBERT JENKINS and CO., Ltd., Rotherham. 4985 A

EXPERIENCED DRAUGHTSMAN REQUIRED IMMEDIATELY for Marine Engineering Works, specialising in the Manufacture of Deck Machinery for Steam Trawlers.—Applications in writing, stating age, qualifications and salary required, to—
JAS. ROBERTSON and SONS (Fleetwood), Ltd., Fleetwood. P6967 A

JUNIOR DRAUGHTSMAN WANTED for General Mechanical and Structural Work, Croydon district.—Address, 4914, The Engineer Office. 4914 A

LADY TRACER REQUIRED AT ONCE, West London district; one with experience of Aero-engine Work preferred.—Address, stating age, experience, and salary required, 4980, The Engineer Office. 4980 A

SITUATIONS OPEN (continued)

REALLY First-class STRUCTURAL DRAUGHTSMAN REQUIRED AT ONCE. Must be quick, accurate and reliable. Knowledge of Bunker Design essential.—Apply, GAS CHAMBERS and COKE OVENS, Ltd., Artillery House, Artillery-row, Westminster, S.W. 1. P7000 A

SENIOR and JUNIOR TOOL DRAUGHTSMEN, with knowledge of all types of Jigs, Tools and Gauges used in production of High-grade Telegraph Instruments. Temporary post only.—Write, stating age, experience and salary required, to CREED and CO., Ltd., Telegraph Engineers, Croydon. 4952 A

YOUNG Energetic DRAUGHTSMAN REQUIRED by Firm of General Engineers in South Midlands. Must have general experience and be prepared to undertake simple designing.
State age, experience, and salary required. Copy testimonials and photograph to be furnished.
Address, P6982, The Engineer Office. P6982 A

SITUATIONS WANTED

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For continuation of Small Advertisements see page 4.

A Seven-Day Journal

French Aeronautics.

MORE money is being spent on air defence in France than elsewhere, the reason being that the service is undergoing a complete and necessarily costly reorganisation. As military aviation requires a reserve of potential pilots, the Air Minister is pushing forward a scheme which will not only train pilots, but will stimulate public interest in air travel. The first thing to be done is to ensure the construction of suitable types of light touring machines. So far, very little has been effected in this direction, because there has been no demand for private aeroplanes, and the few in use are of British make. The Minister is therefore arranging with aeroplane builders to design suitable machines fulfilling conditions laid down by the technical services. These machines are to be shown and tested in competition in October next, presumably during the course of the Aeroplane Exhibition to be held in Paris. If satisfactory types of light aeroplanes are evolved, it is intended to organise an International Challenge Competition, when an opportunity will be offered of testing them against foreign machines. Subsequently, there will be a National Competition, when prizes amounting to 2,000,000f. will be distributed amongst French competitors whose machines offer the greatest security. Finally, the French Parliament has voted a sum of 5,000,000f to be distributed as premiums for the encouragement of touring by air, principally as grants to touring clubs for the purchase of machines.

Associated Electrical Industries, Ltd.

THE thirtieth annual general meeting of Associated Electrical Industries, Ltd., was held a few days ago in London, when the chairman, Sir Felix J. C. Pole, explained that the profit for the year amounted to £365,961, an increase of £107,189 over the previous year. Having regard to the severe competition prevailing during the year, the results, he said, might be regarded as satisfactory, but it was felt that the profits were not commensurate with the high quality of the company's products and the service rendered to its customers. A year ago the shareholders were reminded that notwithstanding the large orders placed by the Central Electricity Board in connection with the "grid" system, there was an excess of manufacturing capacity. That was still the case, and there was no doubt a wide field for co-operative effort within the industry. The steps taken to co-ordinate the activities of the companies embraced in Associated Electrical Industries had already been fruitful of some results and the directors looked hopefully to the future. An important development during the year was the decision to utilise the Edison Swan Electric Company as the merchandising section of the group, and the business in wiring supplies, fittings and radio apparatus formerly handled by the merchandising sales department of the British Thomson-Houston Company had been taken over by the Edison Swan Company. That would be followed by the transfer to the Edison Swan Company of the Metropolitan-Vickers merchandising business. The past year had been marked by an extensive campaign undertaken with the object of improving and cheapening the companies' various lines of apparatus and developing new products. Speaking generally, the works of the group were comparatively well employed during 1929, and the output was satisfactorily maintained. Having regard to the very high standard of the products, however, prices were far too low.

The Late Professor J. Wemyss Anderson.

MANY engineers, both at home and abroad, whose duties have brought them into close touch with refrigerating machinery and cold storage problems will learn with great regret of the death of Professor J. Wemyss Anderson, who retired in 1924 from the John Williams Hughes Chair of Engineering Refrigeration at the Liverpool University, and who also served for some time as Dean of the Faculty of Engineering. Professor Anderson was born at Stoke in Devon in 1868, and received his education at the Park Grammar School, Plymouth. After an apprenticeship of five years with J. Jack and Co., of Liverpool, he joined the Kilbourn Refrigerating Company, of Liverpool, and carried out many refrigerating installations. From 1893 to 1903 he was Assistant Lecturer in Engineering at the University, and when, in 1903, he was appointed Lecturer on Design and Drawing and Dean of the Faculty of Engineering, he gave up his consulting practice and devoted himself to research work. From 1920 to 1924 he was Professor of Engineering Refrigeration. At the request of the Institution of Mechanical Engineers, he reported in 1909 on the position of refrigeration and outlined a programme of research work which was subsequently carried out. Professor Anderson's report was, it will be recalled, followed by the formation of a Research Committee, on which he served under the chairmanship of Sir Alfred Ewing. When the Department of Scientific and Industrial Research established a Cold Storage Research Board, Professor Anderson was appointed as the representative of the Ministry of Food on the Board. He was a member of the Ice and Cold Storage Association, of the Institution of Civil Engineers and of the Institution of Mechanical Engineers, and a past-president of the Liverpool Engineering Society. He read many technical papers on refrigerating machinery and cold storage problems, and his work on vapour compression machines in particular gained for him a leading place in that particular branch of cold storage practice. His death at a comparatively early age will be widely regretted.

The Machine Tool Trades Association.

THE annual report of the Machine Tool Trades Association shows that during 1929 five firms joined and seven firms withdrew from the Association, and that the membership now stands at 110. One of the principal functions of the Association is to protect members against the expense and trouble caused by unnecessary exhibitions. It is, therefore, of interest to note that by resolution of the Council members may exhibit this year without violating their bond at any exhibition promoted by the Society of Model Engineers, the Royal Agricultural Society and the Smithfield Club and by the Society of Motor Manufacturers and Traders so far as small tools and garage machinery are concerned. Action was taken against a member who allowed his name to be advertised in connection with a display of foreign machine tools at the Shipping, Engineering and Machinery Exhibition. The full fine under the Association's bond was imposed and paid. On the other hand, no penalty was imposed on a member whose machines had been exhibited by another firm at the British Industries Fair, 1929, on an undertaking being given that the member would prevent his machines from being exhibited at any future exhibition. The Association took action in connection with the publication in a German paper of an article containing adverse comments on the British machine tool industry. Mr. C. L. Paus, Commercial Secretary of the British Embassy at Oslo, was reported in the article to have stated that in his opinion British machine tools were old-fashioned and higher in price than German machines. It was pointed out to the editor of the German paper that Mr. Paus had not expressed these opinions as his own, but had quoted them as being the opinions of others, probably German machine tool importers. The article further stated that exactly the same opinion had been expressed by Mr. Hums, the British Trade Commissioner in Montreal. It was pointed out by the Association that our Trade Commissioner at Montreal is Mr. F. W. Field, that he had issued no statement of the kind attributed to him, and that no one of the name of Hums exists in the British Trade Commissioners Service.

Charing Cross Bridge.

ON Tuesday the House of Commons Committee finally rejected the Charing Cross Bridge Bill promoted by the London County Council. On April 10th the Committee informed the promoters that it was prepared to sanction the proposals so far as concerned the construction of the bridge itself, but that it objected to that portion of the scheme which involved the erection of a new terminal station for the Southern Railway on the Lion Brewery site on the south bank of the river. An interval was allowed in order to permit the Council to consider alternative sites for the station in conjunction with the Southern Railway and the Underground Company. On Tuesday, however, the Council reported to the House of Commons Committee that no other site was practicable. The Committee was prepared to allow the Bill to be withdrawn so that it might be reintroduced at a later date, but the Council's definite insistence upon the Lion Brewery site eventually led to the Committee rejecting the Bill as a whole. The Bill, it may be added, passed its second reading in the House of Commons by a majority of 230 to 62. It represented five years of negotiation and discussion, but by the action of the Committee it has now been killed. The possibility of carrying out a greatly needed scheme of bridge construction in the neighbourhood of Charing Cross would now appear to have receded for an indefinite time. The underlying assumption involved in the Committee's decision, namely, that it is beyond the abilities of engineers and architects to design a modern railway station which will not be a disgrace or an offence to the eye is, we think, an implication that will be justly resented by the two professions.

The "Grid."

SPEAKING at a luncheon given by the Lord Provost and Corporation of Edinburgh on the occasion of the recent starting up of the Central Scottish Electricity Scheme, Mr. Herbert Morrison, the Minister of Transport, said that the old system of electricity supply involved a tragic and needless waste of valuable plant over the greater part of the 24 hours of the day. It was the purpose of the incomplete legislation of 1919 and 1922 and the more satisfactory Act of 1926, to link up all the great power stations of Great Britain by means of interconnecting lines, thus constituting what had come to be known as the National "Grid." Side by side with that development, unnecessary and uneconomic stations would be closed down and that portion of the electrical demand that was required over a large portion of the day would be dealt with by the most economical stations, whilst the less efficient stations would deal with the peak load. The result would be that electricity would be supplied at lower prices in consequence of the more efficient use of electrical equipment and plant. The standardisation of frequency under the scheme would also bring advantages to consumers in respect of the interchangeability of equipment and fittings, and also to manufacturers of plant by reducing the number of stock patterns. The completion of the work under the Act of 1926 would still occupy some time, but the Electricity Commissioners who had to prepare the schemes, and the Central Electricity Board, were to be congratulated on the rapidity of their work. It was not to be imagined, however, that generation was the only problem to be faced. Economies also had to be effected in distribution. The establishment of the "grid" and the consolidation of generation was involving considerable capital expenditure, which had been incurred in the belief that the average electrical consumption per head would advance from 176 units to 500 units in 10 or 12 years' time. The Minister concluded by appealing to the electrical industry to unite in a big publicity campaign for the wider use of electricity.

An Oil-Cake Explosion.

ON Monday disastrous explosions occurred at the oil-cake and seed-crushing mills belonging to Joseph Bibby and Co., of Liverpool, as a result of which six men were killed and eighty injured. An official statement made by the firm attributes the disaster to the spontaneous combustion of oil-bearing sunflower cake stored in a steel silo. No inflammable products, such as petrol or naphtha, were stored in the vicinity. Two heavy explosions took place. They were accompanied by sheets of flame and yellow smoke. The cover of the silo and part of the roof of the building were blown off and fell a hundred yards away. In 1911 an explosion and fire occurred at the same works and caused the loss of 36 lives and injuries to 100 other persons.

A New Steamer for the L.M.S. Larne-Stranraer Service.

AN order has been placed with William Denny and Brothers, Ltd., of Dumbarton, for a new cross-Channel turbine steamer for the Larne-Stranraer service of the London, Midland and Scottish Railway Company. While following the general lines of the present steamers, the "Princess Maud" and "Princess Victoria," the new steamer will be some 25ft. longer and will embody all the newer improvements in navigation equipment, passenger accommodation, and propelling machinery. The principal dimensions of the new steamer are as follows:—Length overall, 325ft.; breadth moulded, 47ft.; depth moulded, 17ft.; and draught, 11ft. The propelling machinery will comprise a twin-screw arrangement of Parsons single-reduction geared turbines, designed for a trial speed of over 20 knots. Saturated steam will be supplied by Babcock and Wilcox water-tube boilers, designed to work at a pressure of 225 lb. per square inch. The boilers are to be arranged for coal firing by hand. The arrangement of the passenger accommodation has received special attention, and it is understood that a large proportion of the cabins will be of the single-berth type.

The Sale of Old Ships.

IN connection with the discussion of the problem raised by the sale of second-hand ships to foreign owners, the Chamber of Shipping has recently issued a very full statement dealing with the matter, in which the view is emphasised that there is no need for any restriction on the disposal by British owners of their old tonnage. It is stated that it is economically unsound to restrict the sale of such ships, as prices of about £6 per ton can be thus obtained, whereas only £2 per ton is paid for vessels for breaking up purposes. In tables which have been prepared showing the number of old ships sold abroad, both for use and for breaking up, it is shown that the sales in recent years to foreign countries have been normal and rather less than those in pre-war years. Expressed as a percentage of the total tonnage on the Register, they do not amount to more than 3 to 4 per cent. Figures for the years 1912 to 1929 inclusive are given, which bear out the above statement, and show that 171 ships of more than half a million gross tons were sold in 1929, including twelve to foreign shipbreakers, for which a total price of over £3,000,000 was obtained. The report of the Board of Trade Committee on Shipping and Shipbuilding of 1918 is cited to show that the Board then regarded the transfer of vessels from the British register to foreign flags as an important feature of our maritime development, and an index of the relative efficiency of the British mercantile fleet as compared with the fleets of other countries, a position which the Chamber of Shipping holds is still unchanged.

The Lochaber Hydro-Electric Power Undertaking.

No. III. (*conclusion*).*

The Pipe Lines.

IMMEDIATELY beyond the sump, which was referred to in the preceding article as having been provided in order to arrest *débris*, the tunnel trifurcates, and thereafter the water is conveyed in three lap-welded steel pipes, the inner or tunnel ends of which are furnished with cast iron bell-mouths, and which are firmly bedded in concrete in the tunnel excavation. These pipes are 70½in. in outside diameter and ½in. thick, and the lengths just before emerging from the hillside are furnished with anchor rings welded on. The outer ends are flanged and each pipe is connected by means of a taper piece to a stop valve, 54in. in diameter. These three valves are operated hydraulically, and, normally, will remain fully open, being only used in case of emergency. For the time being only two of the valves are in service, since only two out of three lines of pipes lead down to the power house. The third is blanked off. Immediately beyond the stop valves are two automatic butterfly or disc-type throttle valves, 69½in. in diameter, one in each pipe line, which are to come into operation to cut off the flow of water should, by any untoward chance—as, for instance, the fracture of the pipe line—the flow of water increase beyond a predetermined velocity. All these valves, which were supplied by Glenfield and Kennedy, Ltd., of Kilmarnock, are practically identical—saving in size—with those which we described at length in our issue of November 2nd, 1928, in connection with the pipe line for the Maentwrog hydro-electric station of the North Wales Power Company, Ltd., and which were by the same makers. There is no need, therefore, to give a further description in the present instance. There are the same by-pass arrangements for filling the pipe line and duplicate anti-vacuum valves—also supplied by Glenfield and Kennedy—as in the Welsh installation.

* No. II. appeared May 2nd.

Making the Pipes.

The contractor for the two lines of pipes at present in position, each of which is some 3200ft. long, was the South Durham Steel and Iron Company, Ltd., of Stockton-on-Tees. The pipes, which are of mild steel, and are formed of steel plates manufactured by the company, vary in diameter from 70½in. to 65in. and in thickness from ½in. to 1½in. They are in 30ft. lengths and were lap-welded, being made of two or three plates, according to the diameter of the pipe, the plates, after bending, being assembled and secured by bolts through the lapped portion. The seams were heated by specially-designed fires served by water gas, and the welding was performed by hydraulic pressure, the pipe being passed between rollers by the movement of a carriage on which it

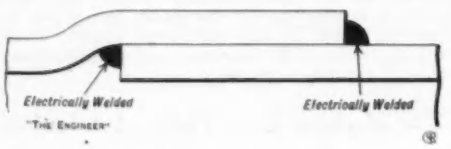

FIG. 13—SKETCH OF PIPE JOINT

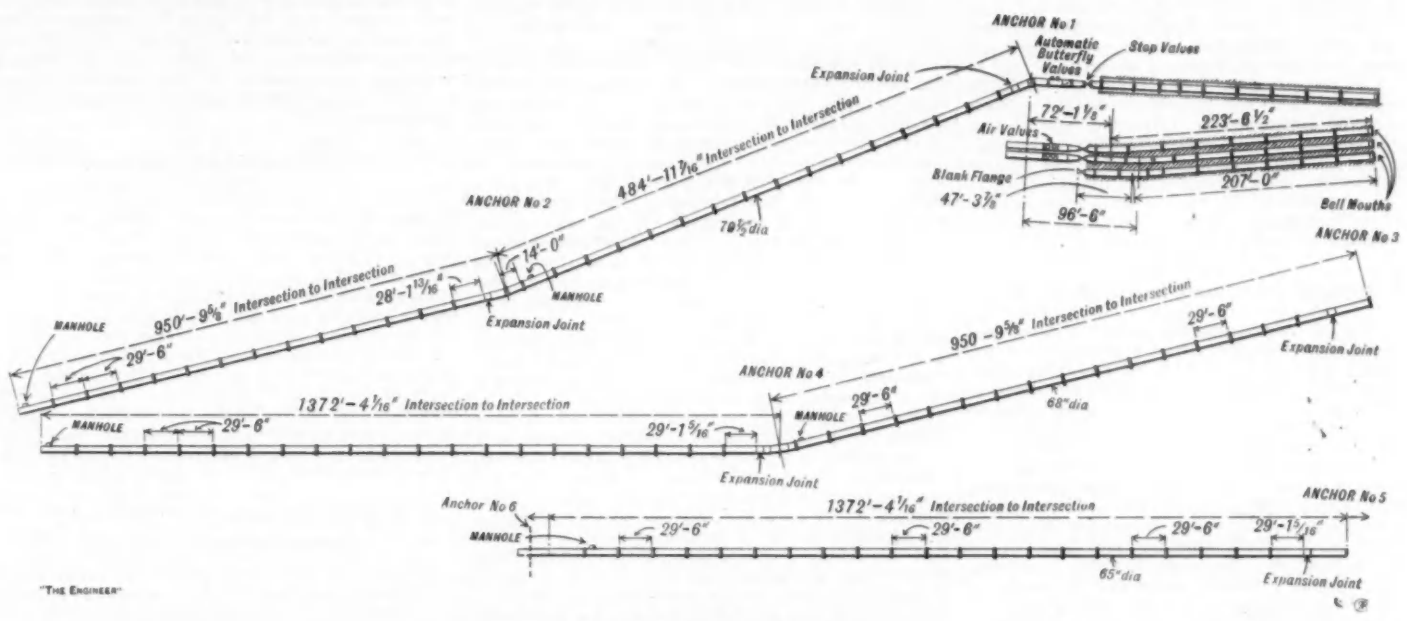

FIG. 14—PROFILE OF PIPE LINE

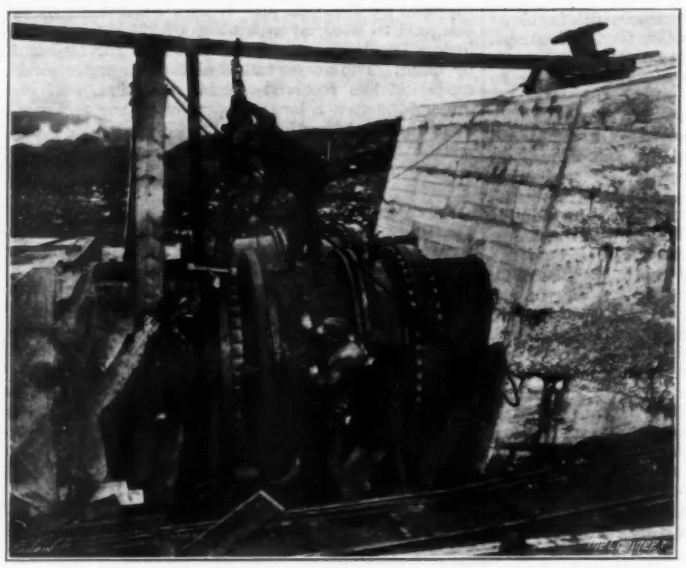

FIG. 15—INSERTING BLANK AT EXPANSION JOINT FOR TESTING

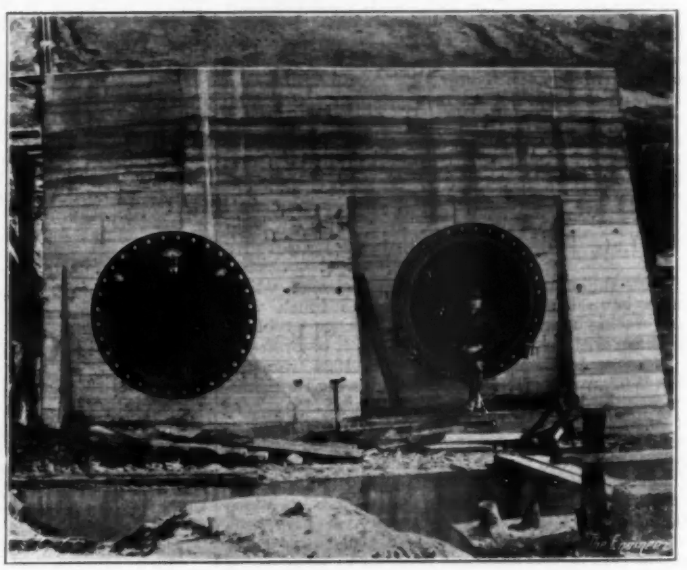

FIG. 16—ONE OF THE PIPE LINE ANCHOR BLOCKS

Laying the Pipe Lines.

The pipe lines are anchored in massive blocks of concrete at six points, and below each anchorage is an expansion joint, with a possible range of travel of approximately 6in., made up of a cast steel body with a mild steel machined slider, the latter having, on the machined surface, a deposit of nickel to resist corrosion. The expansion joints are double flanged to admit of their removal for the purpose of inserting blank flanges during the testing of the pipe lines *in situ*—see Fig. 15. The pipes in the anchor bends are of lap-welded mild steel, the circumferential joints being in a specially constructed press, both electrical and hydraulic power being used in the operations. The male ends were sized so as to give an absolutely metal-to-metal fit. All the pipes were assembled at the maker's works, in order to check the fit and alignment, and each pipe, after assembly, was tested hydraulically to the prescribed test pressure—*i.e.*, 50 per cent. in excess of the pressure due to the static head at which it would have to operate in service. After being tested the pipes were given a coat of Briggs' "Tenax" solution.

A profile of the pipe line is given in Fig. 14. It will be observed that the first anchor comes immediately below the valves at the head of the pipe line. For the first 485ft. or so of the pipe line, *i.e.*, from anchor No. 1 to anchor No. 2, the slope is at an angle of 25 deg., and the pipes, which are 70½in. in diameter, have an average thickness of ½in. and weigh 7 tons each. For the next 450ft.—from anchor 2 to anchor 3—the slope has an angle of 17 deg., and the pipes, which are still 70½in. in diameter, have a thickness of 13/16in. and weigh 9 tons each. At anchor No. 3 the slope does not change, but the diameter is reduced, by means of a taper pipe in each line, to 68in. For 500ft. below anchor No. 3 the pipes average 15/16in. in thickness and the weight is in the neighbour-

hood of 11 tons per 30ft. length. Anchor No. 4, which is just over 950ft. from anchor No. 2, houses a bend pipe which changes the gradient from 17 deg. to 3 deg. 10 min., and below that point the pipes are 68in. in diameter, 1 1/16in. thick, and weigh between 10 and 11 tons each. Anchor No. 5 is a huge block of

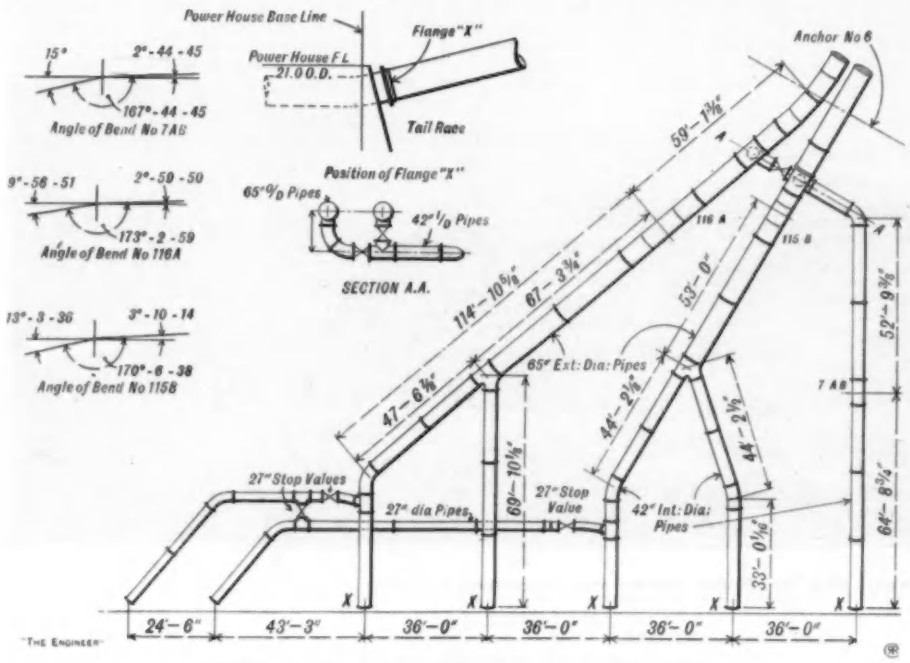

FIG. 17—PRESSURE PIPES ENTERING POWER-HOUSE

concrete weighing over 600 tons, and a taper pipe at that point still further reduces the diameter to 65in., the thickness being increased to 1¼in. A view of one of the anchor blocks, which was taken before the pipes below it were in position, is given in Fig. 16.

SETTING THE ANCHOR PIPES.

The setting of the anchor pipes, especially when they were bends, required a great deal of care. The operation was as follows:—The site was excavated for the foundation and concrete was put in and built up to within 2ft. of the gradient level. During this

FIG. 18—THE PIPE LINE FROM ANCHOR BLOCK NO. 4

operation, boxes were put in to take the holding-down straps by which the pipe was to be clamped into position. Three pedestals were then built up to within an inch or so of the required level, and the pipe, which had previously been drawn on a bogie up the inclined railway at the side of the pipe line by a winch, was rolled across them into the approximately correct position. In setting the pipes three points required special attention: (*a*) the correct position, *i.e.*, up or downhill; (*b*) the correct alignment; and (*c*) the correct level. As the least movement in position would alter the level of the top of the flange end, that position was the first to be determined. It was done by setting up an instrument on a reference peg which marked the centre of the anchorage. From the drawings the horizontal length of the lower leg of the bend was then calculated, and that distance was marked on the outside of the pipe. The instrument was then sighted on a second reference peg and transmitted over. Then by pulling up on, or slackening off, the winch rope, the pipe was moved up or down until the intersection line was brought into line with the theodolite.

Having established that setting, the next point was to correct the alignment. That was done by setting up on a previously erected sighting station, aligning the instrument on a back and fore station, and transmitting the theodolite as before. A plumb line hanging from the erection mark on the flange was

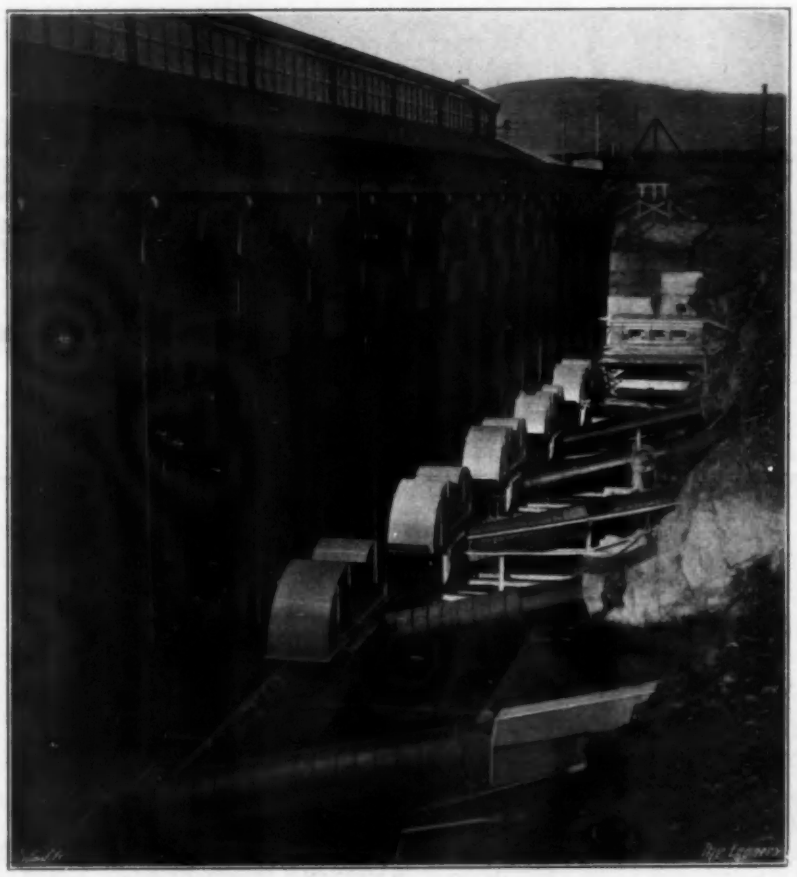

FIG. 19—PRESSURE PIPES ENTERING POWER-HOUSE

accurately made to bisect the flange vertically, the pipe being turned by means of jacks for the purpose. The vertical plumb line was then made—by means of jacks and wedges—to coincide exactly with the cross hairs of the instrument. A plumb line was also made to bisect, vertically, the flange at the other end of the pipe, and the two plumb lines were made coincident with themselves and the instrument. The pipe was then firmly wedged to prevent lateral movement, and by inserting pieces of iron plate under one or other end, as might be required, the top point of the lower flange was raised or lowered until a level staff, held on it, gave the correct reading compared with a reading taken on a known bench mark.

At every 30ft. of its length each pipe line is supported on a concrete pedestal hollowed out to the correct curvature of the pipe and furnished with a mild steel saddle, which, by means of a Stauffer cup and grease pipe, is kept full of grease so as to allow contraction and expansion of the pipe line to take

FIG. 20—A WELDED PIPE JOINT

place without putting tensile or compressive stresses on the joints.

Views of the pipe line are given in Fig. 18, and in Figs. 26 and 27 on page 520. The latter is interesting since it shows practically the whole length of the pipe lines, with the power-house and aluminium factory in the middle distance, while, beyond, may be seen the tail-race discharging into the river Lochy.

WELDING THE JOINTS.

All the joints throughout the two pipe lines were are welded *in situ*, a method never before attempted in this country. The welding was done by means of the Quasi-arc process. For light work, two portable petrol-driven generator sets supplied by W. H. Dorman and Co., Ltd., of Stafford, were used. Each set was capable of operating two welding arcs. For the heavier work lower down the line, where thick pipes occur, two Crompton-Parkinson motor-driven electric welding sets were used, the current supply being 440 volts alternating, three-phase. These two sets supplied four welding points. A sketch of a

THE LOCHABER HYDRO-ELECTRIC POWER UNDERTAKING

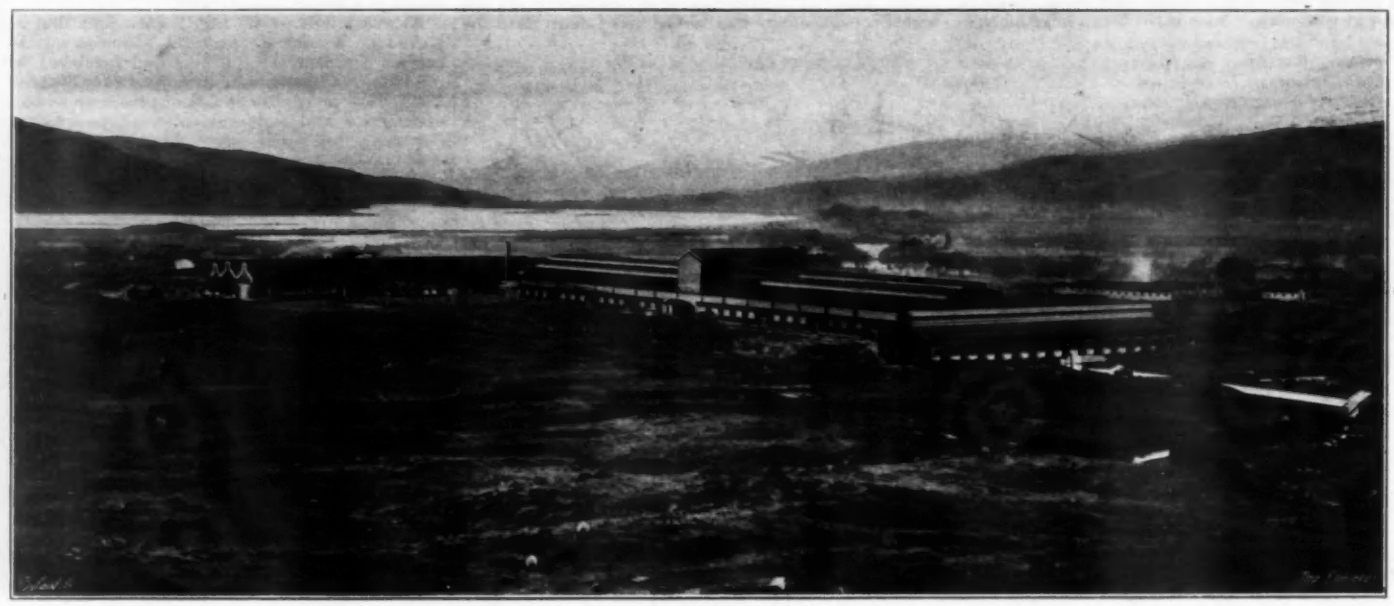

FIG. 21—GENERAL VIEW OF POWER-HOUSE AND ALUMINIUM FACTORY

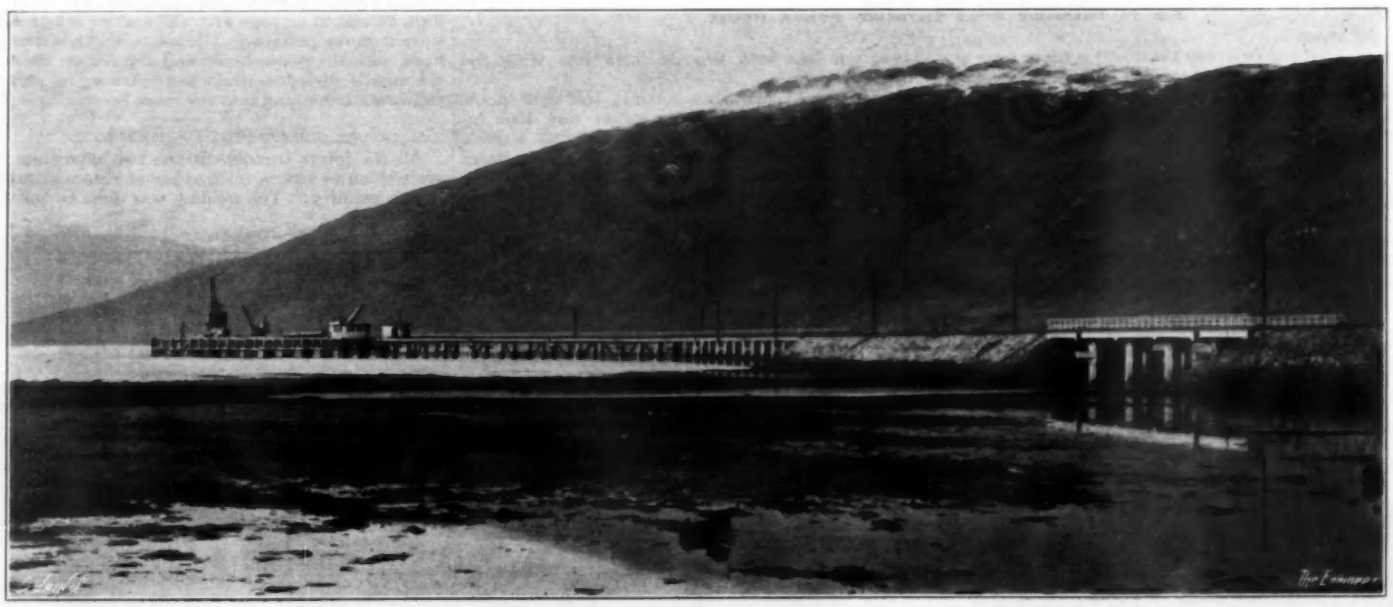

FIG. 22—CONCRETE PIER IN LOCH LINNHE AND BRIDGE OVER WATER OF NEVIS

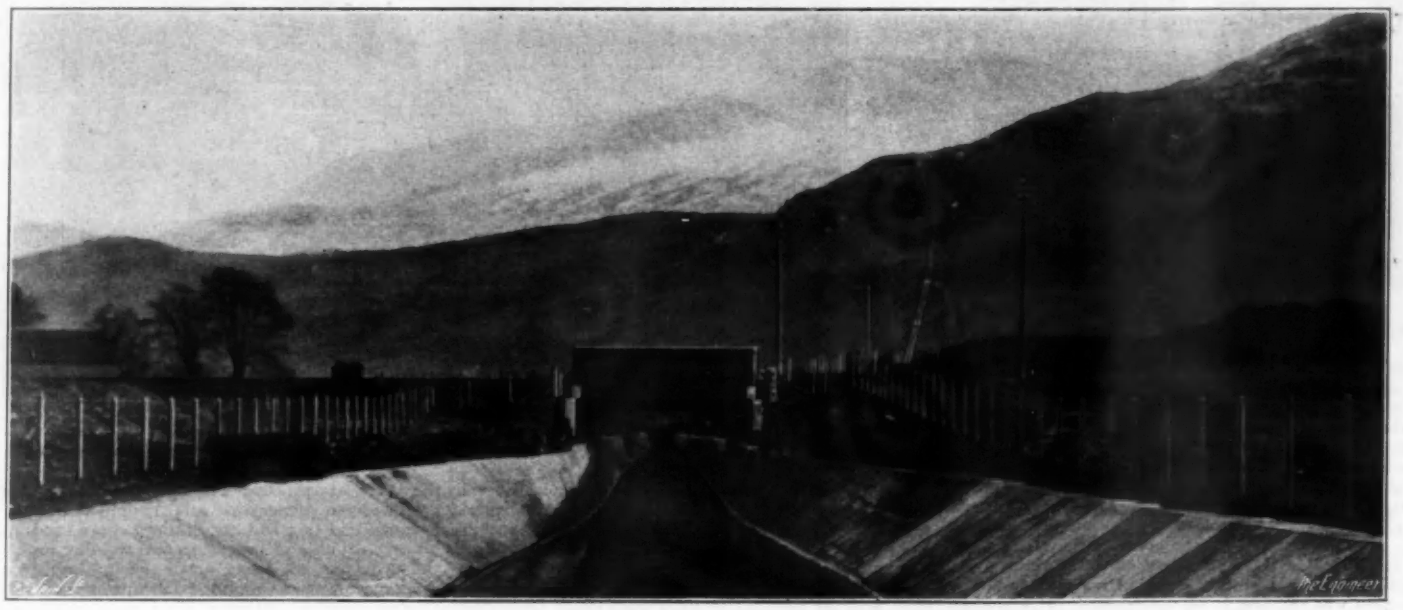

FIG. 23—THE TAIL-RACE LOOKING TOWARDS POWER-HOUSE

welded joint, Fig. 13, has already been alluded to, while a view of a welded pipe is given in Fig. 20.

After reaching anchor 6 the pipe lines bifurcate into the distribution system, and by five lines of 42in. flanged pipes the water is conveyed into the power-house. In addition, two lines of 27in. bore pipes are taken from two of the 42in. pipe lines, these 27in. pipes being for the two auxiliary turbine sets. Fig. 17 shows the splitting up of the pipe lines just before they enter the power-house, while an excellent idea of the whole arrangement is given by Fig. 19, which is a view outside the power-house itself. The engraving also shows the cooling air inlets for the generators and the excavation for the tail-race. The valves for this portion of the work were made by Glenfield and Kennedy.

TESTING THE PIPE LINES.

The two pipe lines were tested separately when in position, each being tested in three sections. The first section was from the control valves in the power-house to the downstream end of the expansion joints below anchorage No. 4. The second section was from this latter point to the downstream end of the expansion joint below anchorage No. 2, while the third section was from the point just mentioned to the upstream flange at the portal intake. As has already been said, a third pipe line for future extension has been put in at the tunnel portal along with the other two pipe lines. This third short length of pipe was tested between the blank cover at the intake and the stop valve, in a similar manner to that employed for the other sections.

Each section was tested to a range of pressure such that, at the lowest point of the section, the test pressure was 25 per cent. above maximum possible static pressure at that point. When the first section of either pipe was tested blank covers were fitted between the first and second, and between the second and third sections, both being filled with water. That was done to enable a pressure of 50 per cent. of the maximum static head to be put on the upstream face of the blank cover between sections 1 and 2, and by that means the effective "pull" on anchorage 5 was reduced to 75 per cent. of the static head at anchorage 4. The same procedure was followed for the second section, but for the top section the arrangement was not required. A maximum test pressure of 432 lb. per square inch was supplied at the bottom of the line adjoining the turbine inlet valves. Each line on the first test proved, we are informed, to be perfectly tight and sound in every way. There was not a sign of leakage anywhere.

We may add that all the steel castings for the distribution system were supplied by Edgar Allen and Co., Ltd., Sheffield, while the cast steel flanges and the cast steel expansion joints were supplied by the Darlington Forge, Ltd.

THE POWER HOUSE.

It was originally intended to construct the power house on the left bank of the river Lochy in a position a short distance below the railway bridge. On going closely into the matter, however, it was found that, by selecting a site some 3000ft. away from the river and sinking the power house to a depth of some 40ft. below ground level, a more economical scheme could be obtained with a slight gain in power. The cheapening was effected in spite of the fact that altering the position necessitated a tail-race 3000ft. long, 1000ft. of which was in tunnel, and it was due to the fact that the cost of constructing this long tail-race was more than counterbalanced by the saving due to the shorter length of pipe lines.

The designs of the power house and factories were carried out under the direction of the British Aluminium Company's staff, chief of whom to be mentioned are Mr. J. S. Bliss, the technical manager, and Mr. A. E. Kinnear, the architect.

The power house is a building 270ft. long by 65ft. wide, and is traversed from end to end by a 30-ton electrically-operated overhead travelling crane, made by Messrs. Vaughan Brothers. As at present arranged, it contains less than half the generating plant which will eventually be installed when the scheme has been developed to its full extent. There are at the moment five main turbo-generator units, each of 10,000 horse-power capacity, supplied by the English Electric Company, Ltd. Each unit comprises a turbine of the Pelton wheel type, driving two generators, all three machines being on one bed-plate. The generators are direct-current machines, which operate at a pressure of 300 volts and run at 250 r.p.m. In addition to the foregoing, there are two subsidiary turbo-generators, each of 1250-kW capacity, supplied by the Metropolitan-Vickers Electrical Company, Ltd. The alternators of these smaller sets, which are three-phase, 50-period machines, wound for 400/440 volts at 600 r.p.m., and are rated at 1562 kVA at 0·8 power factor, are coupled to Boving water-wheel turbines. The alternators have overhung exciters and exciter field rheostats. These two machines are for supplying current for power, lighting, and traction purposes. The generating units occupy the whole space of the power house, as at present constructed, and when the time comes for laying down additional plant the building will have to be extended, and for that contingency provision has been made. The nozzles of the turbines are arranged to operate at 19ft. above O.D., so that with the level of Loch Treig at 783ft. above O.D., the gross head available is 764ft. When the loch is raised, as proposed, to 819ft. above O.D., the gross head will be increased to 800ft.

The tail race, which has a cross section of 17ft. by 8ft., is taken in a direct line to the river, which it enters at right angles to the course of the stream just below the Mallaig railway bridge. It passes on the way under the London and North-Eastern Railway twice and under a public roadway once. At these points concrete bridges have had to be built to accommodate it. The channel is formed in concrete and the inside of the tunnel portion has also been concreted. The fall in the length of 3000ft. amounts to 3ft. A view along the tail-race looking towards the power-house is given in Fig. 23, page 510.

Adjoining the power-house and with its floor some 34ft. above that of the latter is the aluminium factory. A general view of power-house and factory is given in Fig. 21, page 510.

The building of the power-house at such a low level necessitated the construction of an inclined standard gauge railway, some 350 yards long, so that railway trucks might be taken right into the turbine room immediately under the crane. The line has a gradient of 1 in 40, and its construction involved the excavation of a considerable amount of rock. Subsidiary works in the neighbourhood of the power-house include the formation of sidings, the building of new and the

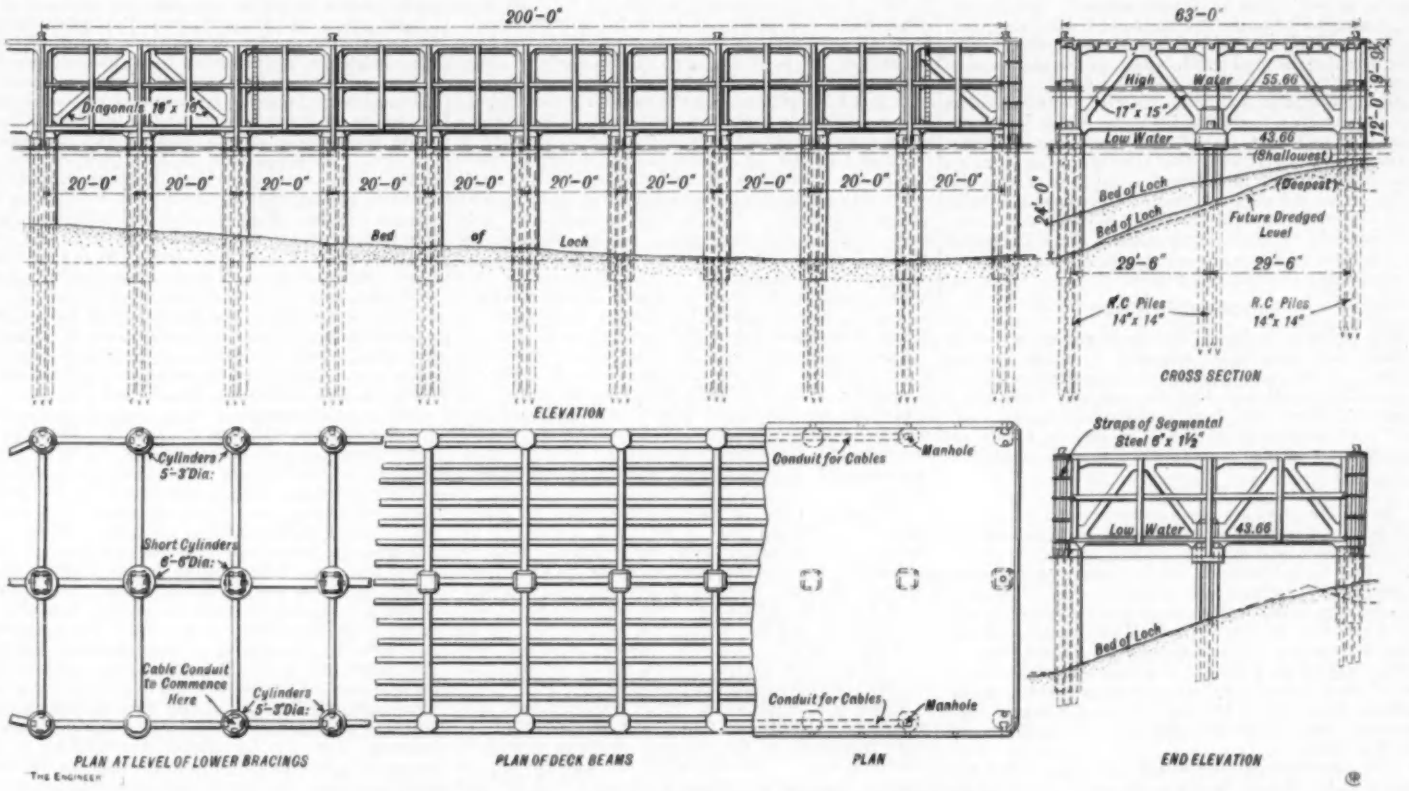

FIG. 24—ARRANGEMENT OF REINFORCED CONCRETE PIER HEAD

FIG. 25—A PORTION OF THE MODEL VILLAGE

diversion of existing roadways, the construction of bridges, &c. All of them are excellently carried out.

THE PIER.

A very necessary adjunct to the undertaking was a pier or jetty at which ships carrying materials to and from the factory could berth. The pier—see Fig. 24 and Fig. 22, page 510—which has been constructed is, including its approaches and a reinforced concrete bridge over the Water of Nevis—see Fig. 22—some 650 yards long. The Water of Nevis is an important stream, which, where it is crossed by the bridge, is 70ft. wide. The jetty stretches out into Loch Linnhe and is curved in plan at its seaward end. It is formed of reinforced concrete on reinforced concrete piles, and in itself is a work of considerable importance. The deck for the final 200ft. is 63ft. wide and alongside there is, even at low water, a depth of 24ft. It is laid with three sets of 3ft. gauge lines of railway, and is equipped with a travelling jib crane which is capable of dealing with loads up to 5 tons. Two lines of railway connect this jetty with the aluminium factory, so that materials can be taken directly to and from the ships on to the site. A line of 4in. pipes has been laid to the far end of the jetty so that ships may conveniently fill their water tanks. Electric current at a voltage of 440 is also available, and the structure is electrically lit from end to end.

THE MODEL VILLAGE.

The scheme included the building of a model village with excellently planned dwellings for the housing of the large number of workpeople who will eventually be employed at the factory. Everything appears to have been done to ensure the health, comfort and recreation of these operatives and their families. A view of a portion of it is given in Fig. 25.

CONCLUSION.

In the foregoing we have endeavoured, necessarily briefly, to describe to our readers in broad outline this fine piece of engineering work. Much has inevitably had to be omitted, but we trust that we have succeeded in giving them a general idea of what is among the most daring engineering exploits which have ever been attempted in the British Isles. When the whole scheme, of which the first portion has now been completed, is carried out in its entirety, it will, as we have said above, be the most important undertaking of its kind in this country, and will rank high among those of a similar character in any other part of the world.

The inception of this scheme is due, as was said above, to Mr. Murray Morrison, M. Inst. C.E., M.I.E.E., who also conducted intricate negotiations with proprietors and others in connection with financial matters. In addition, he has carried out much supervisory and consultative work on the technical side.

In conclusion, we would again bear testimony to the excellence of the undertaking, both in design and execution. Considering the magnitude of the work and the innumerable problems, both in engineering and construction, it is a triumph for British skill and ingenuity and reflects the greatest credit on the engineer, Mr. W. T. Halcrow, of Messrs. Meik and Halcrow, and on the contractors, Messrs. Balfour Beatty and Co., Ltd. The workmanship of the many portions of the work which we examined was in every way first-class. The immediate supervision of the work at the site was in the hands of Mr. James Brown, M. Inst. C.E., as chief resident engineer, who was ably assisted by Mr. R. D. Duncan, Assoc. M. Inst. C.E., who had charge of the Fort William half of the tunnel and other works, and Mr. B. N. Peach, B.Sc., Assoc. M. Inst. C.E., who looked after the Loch Treig half. To these three gentlemen, as well as to Mr. Halcrow, we desire to tender our thanks for courteous assistance.

Aeronautical Progress, 1914—1930 *

By Professor R. V. SOUTHWELL, M.A., F.R.S.

IN 1912 Mr. Mallock addressed this Institution on the subject of "Aerial Flight," and in 1914 Dr. Lanchester took as the subject of his James Forrest Lecture "The Flying-Machine from an Engineering Standpoint."

Remembering that in May of 1914, when Dr. Lanchester spoke, no sense of imminent war oppressed the minds of his audience, I must account it a lucky chance that his review of aeronautical problems should have had a date so little prior to the outbreak of hostilities. For of course it was the War—by which the scientific interest of a few men became, almost literally in a night, a means of success or failure to whole nations—that provided a stimulus for the abnormal development of aeronautics which we have to consider this evening. Let me say at once if anyone in my audience expects to be told that recent advances in scientific knowledge have made those pre-war lectures obsolete, he will be disappointed by my lecture. The kernel of all we yet know of fundamental aerodynamic theory was there to be read in 1914—by such as could understand. It is significant, I think, that the gentlemen who moved votes of thanks to Mr. Mallock and to Dr. Lanchester confessed that the lectures had been more than they could follow. I, for one, am not able to follow them completely to-day; but I have followed them sufficiently to realise how far they were in advance of their times.

Dr. Lanchester began his lecture by emphasising the high resistance of the aeroplane as compared with other forms of transport. In every form, forward motion in a horizontal plane is opposed by some kind of frictional force, roughly proportional to the weight which is moved. The coefficient of tractive resistance is defined as the ratio of resistance to weight or—in aerodynamic terminology—of drag to lift; it can be expressed in terms of the least slope down which motion is possible under gravity alone—because, evidently, in these circumstances, the ratio of drag to lift is the tangent of the angle of slope. According to figures given by Dr. Lanchester, a slope of 1 in 50 is sufficient for the motion under gravity of a road vehicle with pneumatic tires, 1 in 80 for a sleigh—with wooden runners—on smooth ice, and as little as 1 in 400 for a train moving slowly on rails. Compared with these figures the least slope along which an aeroplane can descend steadily under gravity seems very steep. Mr. Mallock remarked in 1912 that no aeroplane possessed a gliding angle as flat as 1 in 7, and that 1 in 5 was more nearly what might be expected. According to Dr. Lanchester, the military trials of the same year gave no result as good as 1 in 7, but he quoted the figures 1 in 12 for the Wright machine and 1 in 13·5 for the Voisin.

Present-day figures show little if any advance. From analyses made for a number of service aircraft it would seem that 1 in 10 is about the flattest gliding angle of an aeroplane fitted with a water-cooled engine, and that machines with air-cooled engines are slightly less efficient. The gliding angle of the Fairey "Postal" aeroplane—1 in 14·5 about—is a quite outstanding result.

We may remark, in passing, that from the standpoint of forced landings in restricted spaces not the flattest gliding angle, but the steepest, may be desirable. The "Autogyro" of Senor de Cierva can descend at angles as steep as 36 deg., the "Atlas" at 24 deg. to the horizontal. The latter is a two-seater aeroplane by Messrs. Armstrong, Whitworth, having unslotted wings. Lift slots of the Handley Page type give smaller landing speeds, but do not, as a rule, modify the gliding angle appreciably.

Speed is a requirement which conflicts with that of mechanical efficiency; for "at high speed the . . . body resistance of the machine becomes disproportionately high." According to Dr. Lanchester, the highest speed at the military trials of 1912 did not touch 70 miles per hour. He spoke of 80 miles per hour as within the range of future possibility for a machine weighing 1200 lb., and he remarked that a demand for higher speeds was likely to be met only by building larger and heavier machines. "The direction in which advance is necessary before any great increase of speed can be realised is that of reduction in the weight per horse-power of the motor; it is difficult to believe that any great reduction in weight can be effected on the best figures available to-day, without an undue sacrifice of reliability."

In this field, at least, we can record substantial advances. Passenger craft to-day have cruising speeds commonly of the order of 95 miles per hour; military machines can fly at nearly twice that speed, and the world's record—held by Squadron-Leader Orlebar, Supermarine S. 6 with Rolls-Royce engine—is 357·7 miles per hour. What is the explanation of this stupendous increase? (It is stupendous, if we remember that a speed of 350 miles per hour, as compared with 70 miles per hour, demands that the power expended shall be multiplied by 125.) Partly it has been gained by advance in size, as Dr. Lanchester foresaw, and in part by cleaner design; but mainly, I think, by advances in a field which he did not consider to afford much promise—the high-duty internal combustion engine.

Next among the criteria of performance I shall consider range. Dr. Lanchester, in 1914, estimated the limiting range of the aeroplane as about 600 miles, "a limit of possibility, which . . . may prove attainable by the gradual refinement of existing method." Under abnormal conditions, with a machine specially designed for long-distance flying, he was prepared to contemplate a range of 2000 miles, and discussing the possibility of crossing the Atlantic by air, he said that evidently there was "a possible chance of successful achievement" if, as was believed to be the fact, a general eastward aircurrent exists at high altitudes, "sometimes estimated at 20 to 30 miles per hour."

Let us briefly consider the factors in this problem, so far at least as is necessary to realise their complexity. Level flight involves a resistance which is roughly proportional to the load carried, and which rises sharply with the speed. Long range demands a heavy load of fuel and the highest possible figure for "miles per gallon." Evidently, then, there is some optimum speed; the aeroplane should fly neither very fast nor very slow. Its problem is different from that confronting land or sea transport, where, roughly speaking, the range increases steadily with reduction in the speed. Its weight will vary widely during the flight, as fuel is gradually consumed. The most difficult conditions occur at the start, when it has to leave an aerodrome loaded to its maximum capacity. If found desirable we can, as its weight decreases, ascend to higher altitudes and, with our speed through the air unchanged, fly still at the most economical angle of attack, against a resistance which has become less on account of the reduced density. At the end we shall thus gain several miles, as we glide down under gravity from the height that has been attained. But the engine is an additional factor. It is not indifferent to rates of revolution, nor to the density—or pressure—of the air with which it is supplied. The airscrew also presents its problems, especially at the moment of "take-off." We can fit an airscrew of variable pitch, and a blower to maintain air pressure in the intake pipe; but these represent additional weight, which must be carried all the way. Will they justify their existence, by increasing the distance flown?

You will realise, I think, that many considerations are involved. Time will not allow us to discuss them. Let us see what has been actually achieved, and what is its significance in the light of Dr. Lanchester's forecast. In September of last year, Coste and Bellonte, in a Breguet machine with a 600 H.P. Hispano engine, flew a distance of 4912 miles in a non-stop flight. This is the world's record; but a closely comparable achievement stands to the credit of Great Britain, in a flight made from Cranwell to India—3950 miles—by Squadron-Leader Jones-Williams and Flight-Lieutenant Jenkins, in the Fairey-Napier monoplane to which we have already referred in connection with aerodynamic efficiency. Actually a ground mileage of approximately 4290 miles was covered—for the most part against a head wind—in 50 hours 37 minutes.

Range has depended always upon the engine, but in different ways at different times. In 1906, when the first official record—220 m.—was won by Santos Dumont, a flight began when the engine could be induced to start, and it stopped with the engine. Later the engine dominated the stage as fixing the weight which had to be lifted; but now—if we permit refuelling in flight—the working life between overhauls is again the deciding factor, flights of 420 hours' duration and upwards having been made in America. Contrary winds of normal strength are losing their importance, as the India flight reveals.

When Dr. Lanchester contemplated a range of 2000 miles, it was on the basis that petrol accounted for one-third of the total weight. In the India flight almost exactly 7000 lb. of fuel were expended, representing just one-half of the total weight. That, and increased size—Dr. Lanchester was thinking of aeroplanes of one-tenth the weight—and in particular cleaner design and better fuel consumption, are the reasons why achievement has so far outrun his predictions.

Rate of Climb and Maximum Altitude.—These, again, are qualities not so much of the aeroplane, regarded as an aerodynamic problem, as of its engine. I shall discuss them only as far as a comparison can be drawn between the figures of 1914 and of 1930.

In 1914 Dr. Lanchester gave it as his opinion that for ordinary cross-country flights under fair weather conditions, a margin of power representing an upgrade of 5 or 6 per cent., would seem to be ample; "there is probably no real advantage in any greater provision." For service purposes he remarked that climbing power was essential; and in illustration he quoted from two specifications of the Royal Aircraft Factory:—

	Normal flight speed. Miles per hour.	Rate of climb. Feet per min.	Equivalent gradient.
R.E. 1 (reconnaissance aeroplane)	70 ..	600 ..	1 in 10
F.E. 3 (gun-carrying aeroplane)	75 ..	350 ..	1 in 20 (about)

Regulations of secrecy prevent me from giving the best achievements of the present day; but the Air Ministry has furnished me with representative figures for comparison, as follows:—

	Normal flight speed. Miles per hour.	Rate of climb. Feet per min.	Equivalent gradient.
Day bomber reconnaissance aeroplane	177 ..	1450 ..	1 in 10
Single-seater fighter aeroplane	174 ..	1700 ..	1 in 8·4

Altitude, of course, is a different problem, and it was practically untouched in 1914. Dr Lanchester said nothing about it. I have remarked that it depends mainly on the engine, and this is true in so far as the aeroplane is relatively indifferent as to the atmosphere in which it flies, whilst decreased density and temperature entirely change the conditions under which the engine works. But there is another factor, no less important—the pilot's physical reaction to these extreme conditions, and his need of oxygen apparatus and electrically heated garments. We cannot spare time to discuss these. It must suffice to say that just one year ago Neuenhofen of Germany, in a Junkers aeroplane with a Bristol "Jupiter" engine, ascended to 41,795ft. At this height the temperature is about 60 deg. Cent. below that at ground level, and the atmospheric pressure has fallen to less than one-fifth of its normal intensity.

Finally, a word about structural design—the problem of adequate strength. This is essentially an

* The Institution of Civil Engineers. The thirty-sixth James Forrest Lecture. May 6th. Abridged.

engineering problem, and, as befitted his title, it was fully discussed by Dr. Lanchester. The principles have not changed, and still, as in 1914, our Load Factors Committee has to choose between two possible alternatives, either "to define the worst that the pilot is able to do and specify the factor by which the normal stresses must be multiplied in order to represent the actual stresses," or to "specify arbitrarily a factor of safety, and . . . tell the pilot just what he is permitted to do, and just what he cannot undertake without risk." Still, if the pilot is anxious to wreck his machine, the way to do so is the same—while his aeroplane is diving at high speed he must sudenly jerk his elevator into the position corresponding with its landing speed, and so impose upon the wings a load which is multiplied in some large ratio, the square of the ratio which these two speeds bear to one another.†

Progress, however, has been made, and in two directions. In theoretical design by the elaboration of more precise methods of stress calculation, whose reliability has been checked by careful tests of aeroplanes to destruction; and in methods of manufacture, particularly by the development of metal construction for the essential parts of the structure. But meanwhile the problem has become more difficult; for speeds, as we have seen, have increased beyond all expectation, and when we double the speed we increase the load four-fold. It cannot, I think, be claimed that the aeroplane of to-day is much stronger than that of 1914, in relation to the duty which it is required to perform; but it must be accounted satisfactory progress that structural strength has kept pace with performance, that the risk of breakage in the air should not long since have called a halt.

One remark should perhaps be made. We are forced, it seems, to-day to discard the first of Dr. Lanchester's alternatives. We cannot now afford to build a machine which its pilot cannot break. I do not think that this is matter for alarm. We do not contemplate, when we build a racing car or motor cycle, that the driver will be so blind to his own interests as to drive badly, simply in order to test the strength of his vehicle! Moreover, the physiological factor has begun to assume importance—accelerations amounting to ten or twelve times that of gravity, such as have been measured in special tests made in America, produce temporary blindness, or worse, in the pilot who is exposed to them, equally with his machine. It is of no use to provide him with an unbreakable aeroplane, if we kill him in other ways!

To summarise this hasty review of sixteen years' achievements: Safety has been attained, with some approach to comfort. What mainly delays comfort is noise. Aerodynamic efficiency has been slightly improved, in spite of increased speeds; and we have seen that progress in this field is limited by factors which Dr. Lanchester explained in 1914, and which we cannot hope to evade. Range has been multiplied by more than 13, rate of climb by 3, altitude by nearly 3, speed by nearly 4—and structural design has not fallen behind. I have spoken of metal construction in relation to strength, and I have emphasised that performance, in general, depends upon the engine rather than on the aerodynamic properties of the aeroplane. Let us then consider what advances have been made in engine design during the last sixteen years.

Dr. Lanchester mentioned that many engines, at the time of his lecture, combined with a weight horse-power factor of about 4 a degree of economy that compared well with the best automobile practice. I have already quoted his opinion that great reduction of weight was not likely to be effected, unless by considerable sacrifice of reliability.

Here, we may safely assert, there has been progress greater than Dr. Lanchester foresaw. I have extracted the figures in the following table from an article in *Aircraft Engineering* on the Aero Show of 1929:—

Name.	Type.	B.H.P.	Weight.	Fuel.	Oil.
			Lb. per B.H.P.	Lb. per B.H.P. hour.	Lb. per B.H.P. hour.
Armstrong Siddeley Jaguar	Radial air-cooled	400 (at 14,500ft.)	2·32	0·57	0·026
Bristol Jupiter IX.F.	Radial air-cooled	515	1·75	0·52	0·028
Napier Lion XI.	Broad-arrow water-cooled	530	1·88	0·50	0·024
Rolls-Royce H.X.	60° V. water-cooled ..	825 (at 4000ft.)	1·77	0·488	0·013

The Napier "Lion" VII. *b*—a racing engine of 875 B.H.P.—is credited with a "dry weight" of only 1·06 lb. per brake horse-power. Its figures for consumption are not available.

As evidence that this reduction of weight has not entailed a sacrifice of reliability, I may mention that Imperial Airways frequently obtain 400 hours' running between overhauls. On the Jaguar geared engine they are even getting 600 hours. These are extreme figures, indicating the benefit of working normally below "full throttle"; but even in Iraq as much as 200 hours is often attained, and an average figure is 250–300 hours.

But when range is increased, economy in fuel consumption becomes more important than low weight per horse-power, and "no one so far," as Mr. Pye has remarked in a recent lecture, "has bothered seriously about fuel consumption." It is clear that much can be done. For recent experiments have shown that among identical aircraft, flying together in formation, some use 50 per cent. more fuel than others! Research is now in progress, aimed at the perfection of an automatic device for keeping the fuel-air mixture correct, both for change of altitude and with change of engine throttle.

Apart from these, the outstanding problems of design are to combine small frontal area with adequate cooling, and to achieve perfect balance and even turning moment. Torsional vibration of the crank shaft is a menace which needs careful watching at the speeds now in common use, and its prevention demands, *inter alia*, very stiff crank shafts. It is mainly for this reason that the eight-cylinder-in-line engine is now defunct, and that cylinders have been crowded more and more closely together. An extreme example of this tendency is seen in the Rolls-Royce "F" engine, where adjacent pistons are only ⅛in. apart.

Improvement in thermal efficiency can come only from higher compression ratios. But these introduce difficulties through overheating of the valves, and it seems possible that for this reason the sleeve-valve engine may come into more general use. Alternatively, the Diesel engine, with its more efficient cycle, may prove to be practicable without undue cost in weight. The engines of R101, though heavy, consume 20 per cent. less fuel than the average petrol engine. Of the internal combustion turbine I do not propose to speak. Everyone wants it, but no one more than the aeronautical engineer, who sees in it the ideal form of prime-mover from an aerodynamical point of view.

Among other tendencies of modern design I may mention the employment of the wing surfaces themselves for cooling; the use of special cooling fluids of high boiling point—*e.g.*, ethylene glycol—with consequent reduction in the frontal area of the radiator; the development of cowling and of other devices—*e.g.*, the "Townend Ring"—for lessening the resistance associated with the air-cooled engine; the increasing preference for speed reduction gears—in contradiction of Dr. Lanchester's dictum that "for flight-speeds of 50 miles per hour and upwards the balance of advantage lies definitely with the direct-coupled propeller"—the development of "superchargers" for high-altitude flying, and recognition of the importance of designing aeroplane and engine as a single structure.

In essentials the aeroplane has not greatly changed since 1914. The relative advantages of monoplane and biplane—discussed by Dr. Lanchester—are still a matter of debate. The skeleton or fundamental structure by which the load is carried is arranged very much as it was then. Undercarriages still waste power by their resistance, yet can hardly be suppressed and have not yet been made satisfactorily retractable.

Inventors, of course, are always with us, casting doubts on the question whether the evolution of the conventional aeroplane is rightly described as a "survival of the fittest"; whether it is not rather advancing towards a cul de sac, as did the mammoth and the dinosaur. Three recent attempts to break away from tradition are: the "Pterodactyl," or tailless aerpolane, of Capt. G. T. R. Hill; the "Autogyro," of Senor de Cierva, and the "Helicogyre," of Signor Isaaco.

None of these innovations has sufficiently established itself, as yet, to be properly included in my review. Capt. Hill's original (light) aeroplane proved to be very satisfactory in regard to stability and control, and he is at present engaged at the Westland Works in producing a heavier machine. The autogyro, as everyone knows, has been flown successfully, and it has proved to be very safe both to fly and, what is even more important, to land. But it appears—I am quoting the expressed opinion of the Director of Scientific Research—that we may have to be content with a drop in top speed, rate of climb and fuel economy, in order to reap the great advantages which it possesses in respect of safe landing. Senor de Cierva has himself given this year a comparison of existing autogyros of several types with the best equivalent aeroplanes. He summarises the position thus:—Top speed, 5 to 10 per cent. less; rate of climb, 20 per cent. less; steepness of climb, 50 per cent. less; minimum horizontal speed, 50 per cent. less. And landing, meanwhile, is losing its terrors for the ordinary aeroplane, now that Mr. Handley Page has introduced the "auto-slot."

As for the Helicogyre—we all wish it well, and we admire the readiness which the Director of Scientific Research has shown to accord fair trial to any idea which reveals real ingenuity and gives promise of success. But the more conservative of us are inclined, perhaps, to look with some apprehension upon a design of which the principles are, in so literal a sense, revolutionary.

I have remarked that safety, in 1914, was hardly a quality that men associated with the idea of mechanical flight. Mr. Mallock, two years earlier, had remarked that with the aeroplanes then in use it appeared to be "not much more troublesome to learn to fly in still air or a uniform wind than to learn to manage a bicycle," but that "in gusts and eddies the difficulties of balancing are formidable and of many kinds." He had spoken of current theories of stability as "correct so far as they go, but nothing like complete," and he had confined his remarks on safety, in the main, to the aspects of strength and of the possibility of automatic control. Dr. Lanchester went into greater detail regarding questions of strength; but he, too, said relatively little about stability, considering that "the engineer can well afford to leave questions of this character in the hands of the specialist." He remarked that stability had, up to date, been treated too closely on mathematical lines, and gave it as his deliberate opinion that there was very little room for useful work unless rigidly and directly supported by experiments.

Almost as he spoke, the work was being done at the National Physical Laboratory, where Bairstow and his colleagues started a campaign of experimental measurement—to determine the quantities known as "stability derivatives"—which has been in progress ever since; and at the Royal Aircraft Factory, where Edward Busk, by small changes in the position of the centre of gravity and in the areas and arrangement of the tail surfaces, succeeded in transforming the unstable BE2A into the stable BE2C.

Busk was killed in November, 1914, and the work which I have just described was completed before the War. But notwithstanding this, I think it may reasonably be claimed that safety is a "post-1914" achievement; for increased performance has on the one hand lessened the relative dangers of gusts and eddies—the main difficulty at the time when Mr. Mallock lectured—and on the other hand it has introduced potential dangers of its own, which belong properly to my period.

Stability alone is not sufficient provision for safety. In saying this I am in no way trying to belittle the importance of that classical stability theory of which Bryan laid the mathematical foundations and Bairstow and his colleagues the experimental superstructure. My point, in a word, is this. Until stability was understood—so long as every aeroplane called for constant vigilance on the part of its pilot, to avoid what Dr. Lanchester termed "catastrophic instability"—no problem could be more urgent; but, understanding of the classical theory has not been found a sufficient equipment against the dangers of the air. Problems have arisen, out of accidents in flight, for which the classical methods, based on the theory of small oscillations, are not adequate. I turn for the moment to some of these.

It is hardly necessary, to-day, to describe the phenomenon of "spinning." Practically everyone knows the circumstances; that "stalling" of the wings—that is, their attainment of an angle of incidence corresponding with maximum lifting power—results in a tendency of one wing to drop, and the initiation of a spiral motion—which may be perfectly steady.

Now, stalling may occur inadvertently. It is specially liable to occur when the pilot is endeavouring to climb as fast as possible, in order to avoid some obstacle which is in his path. And the steadiness of the spin is its peculiar danger. Unless a recovery is made the aeroplane will continue spinning, right on to the ground. Many fatal accidents occurred in this way during the war, when training had to be hurried and pilots flew with very little experience.

In explaining what I mean by "stalling," I have directed your attention to the source of the trouble. It is the phenomenon known as "autorotation." In normal flight, an increase in the angle of incidence means an increase in lifting power; but eventually a limit is reached—the stalling angle—beyond which further increase of the angle does not increase, but decreases, the lift. If, then, the pilot tries to climb too rapidly, and "stalls" his wings, the nose of his aeroplane will go down, and he will begin to descend—still with his wings at a large angle to the relative wind.

Now comes in the tendency to "autorotation." Any tendency to rotate, in either direction, will now be seized upon by the wings, and the aeroplane will descend, steadily turning, in a state outside the pilot's power of control. And this is the important point. His instinct is to try to pull his nose up, to avoid the ground; but we can see that his only chance of safety is to put it down, so as to reduce the angle of his wings to the wind. Now that this is understood, spinning, except close to the ground, has no terrors for the skilled pilot; it is, in fact, a manœuvre of some value in air fighting.

For this advance we are indebted to the courage of Major Goodden and Professor Lindemann, who dared to put their aeroplanes deliberately into a spin, and proved that recovery could be effected by pushing the stick forward; and to the insight of Professor Bairstow, who suggested in 1918 that the explanation of the paradox was to be found in "autorotation."

† In exceptionally tight turns, such as are demanded in the Schneider Trophy Race, loads have been multipled by more than 6.

But the danger of the spin is not yet gone entirely. I think it was in America that attention was first directed to the "flat" spin. It appears that in some circumstances the rotation may become so rapid that the centrifugal forces overpower the aerodynamic, and the aeroplane, more or less rapidly, assumes an attitude nearly horizontal.

The aeroplane is no longer boring its way down a corkscrew path; it is falling like a leaf—almost flat, and with a high rate of spin. And now the trouble is, that in these circumstances the fin and rudder—which should check the motion—are largely "blanketed" by the body and tail surface; possibly some revolutionary change in design—as a tail set back behind the fin—will be necessary if the danger is to be removed entirely. Weight distribution, too, is important, since there are gyrostatic couples tending to hold the nose up. The rate of turning is fast—as high as one complete revolution in one second—and the axis of spin may coincide very closely with the centre of gravity. Naturally the physiological effects are serious, and a pilot may lose the judgment which is necessary for control.

We cannot yet say that a satisfactory solution of the "flat spin" problem is in sight. By Air Ministry instructions, it has been placed right in the forefront of our research programme.

Eventually, we may hope, the problem of spinning will be solved—in the sense that no aeroplane will exist that cannot, at the pilot's will, be brought out from a spin that has started. But even then we shall not have disposed of the whole difficulty; for recovery must entail time and height, and we shall not have saved the pilot whose machine begins to spin at a low height above the ground.

What is wanted is something more—that attainment of the stalling angle shall not involve a loss of adequate control. To Professor Melvill Jones belongs the credit for having first focussed attention on this problem—the "problem of low speed control." In 1920 he was instrumental in starting a systematic investigation by a special sub-committee of the Aeronautical Research Committee, and that investigation, he, as Chairman, led to ultimate victory in 1925, when an aeroplane modified in accordance with the Sub-committee's recommendations was proved at Farnborough to be capable of flying steadily and straight, and of performing normal evolutions, as well above as below stalling incidence.

More recently, Mr. Handley Page has succeeded in devising an automatic mechanism—the "auto-slot"—which will produce a like effect. The auxiliary aerofoil at the leading edge is fitted in such a manner that the aero-dynamic pressures to which it is subjected keep it shut at normal angles of incidence, but cause it to open, with consequent increase in lifting power as the stalling angle is approached. The device is amazingly effective, and it has rapidly come into general use on all classes of aeroplane. But the question is still open, whether its automatic action cannot usefully be made dependent in some way upon the precise position in which the pilot has put his ailerons. Research on this and on allied problems is proceeding at Farnborough and elsewhere.

Increasing speeds, as I have shown, have brought new problems in their train—a need of greater strength in construction, better undercarriages, better landing facilities. But the subtlest trap that they have laid so far may be seen in the phenomenon of wing flutter—the latest of the problems with which post-war developments have confronted the Aeronautical Research Committee.

Suppose that we have a monoplane wing moving in a straight path through the air. If its incidence is increased towards the tip, by a straining action which produces twist along its length, elastic restoring forces will be brought into play, which tend to restore the original configuration; and all that can happen, if the speed is low, is an oscillation, or vibration, of the wing which gradually decreases in intensity as energy is dissipated by the internal friction of its structure. But the elastic restoring forces and the internal friction are not the only forces which are operative; twisting of the wing will involve aerodynamic forces, too, and these if they acted alone—on a wing left free to turn—would increase its incidence still further. The reason why they do not do so always is that generally they are not sufficient to overpower the elastic constraints.

But the aerodynamic forces increase with the wind speed—they will be quadrupled if the wing moves twice as fast, and the elastic forces, meanwhile, will remain unchanged. At some speed the aero-dynamic forces must predominate. Then the wing will twist, and unless its speed be slackened, it will not return.

There are other possibilities. Consider a wing of conventional type, having an aileron which, in the absence of constraint imposed by the control wires, would tend to descend by reason of its own weight; and imagine that, as the aeroplane travels forward, its tips meet an upward "bump." They will rise suddenly, lifting the aileron hinge; but the aileron will tend to lag behind, since its centre of gravity lies behind the hinge. Now this means that the camber of the wing is increased, so that the lifting power of the wing tips is even greater than before, and the aerodynamic forces tend to lift the aileron, too. Before the aileron is well under way, the wing tip will have reached its highest point and will be descending, so that the aileron, relatively to the wing tip, is "set up." Thereby it brings a downward force on to the wing, which descends, but still in advance of the aileron. We have a mechanism here which is competent to produce a periodic bending of the wing. We call this "fluxural-aileron flutter." It may be remedied by arranging that the centre of gravity of the aileron shall lie on its hinge, or even slightly ahead.

Thus we see that two kinds of trouble may be expected. A divergence, in which the wing is wrenched as by a steady load, or an oscillation, causing vibratory stresses in the wing structure which may result in damage from fatigue. Both effects may be observed in the behaviour of leaves in a wind. In both the essential condition is that the aero-dynamic forces shall overpower the elastic restoring forces and the internal friction; so in both we have the phenomenon of a "critical speed."

The worst, as being the most probable, type of flutter is that which involves motion of the ailerons. This motion may cause the stick to be wrenched from the pilot's hand; and in a conventional aeroplane, provided that the wings vibrate in anti-phase, so that one aileron is going down as the other goes up, it is opposed by no resistance other than the relatively small constraint which can be exerted by the pilot himself. But suppose that we made the aileron control as nearly irreversible as is the steering control of the average car? Just as road shocks to the wheels are by this means prevented from being transmitted to the driver's arm, so, in the aeroplane, any tendency of the ailerons to flutter would be resisted by the irreversible control. And if aileron flutter is prevented, more than half the battle is won! The question then arises, Would pilots have insuperable objections to the idea of an aileron control in which the sense of "feel" is largely removed? From analogy with the motor car, I should be inclined to say, No; and the recommendation "irreversibility of aileron control" was, with some misgivings, placed at the head of the list. It has been gratifying to find that many of our most experienced pilots take quite kindly to the idea. I fancy that more would do so if the alternative were better realised. At the moment, interest has shifted to the problem of flutter in the tails of aeroplanes and in air screws.

Early this evening I spoke of three basic qualities which are demanded of the aeroplane—namely, safety, comfort, and performance. The last we have seen to be in the main a problem for the designer, and, more especially, for the internal combustion engineer. Safety, as my examples will have shown, has been attained only by long and arduous research. There remains for discussion only comfort. This third requirement, which at first sight might appear beneath the notice of a technically minded audience, does, as a matter of fact, present problems in which the interdependence of abstract science and engineering is particularly close.

What mainly stands in the way of comfort is noise—from the engine and from the air screw. The noise from a high-speed air screw is of particularly painful quality, and it would seem that trouble must be expected as tip speeds approximate to that of sound. So we enter the field of hydrodynamics of a compressible fluid, a subject equally painful from the mathematical standpoint! Important advances have been made in recent years by Professor G. I. Taylor on the side of theory and by Sir Thomas Stanton and Mr. G. P. Douglas on the side of experiment. I regret that lack of time prevents me from describing them to-night.

I must also leave untouched the work which has been done by Dr. Tucker, Dr. Paris, Mr. Davis, and others on the acoustical problems of noise measurement and noise prevention. Work on the first is largely shrouded in official secrecy, and work on the second is—in relation to aeroplanes—still in its early stages, as residents in the Croydon district will agree. In their scientific aspects these problems are as fascinating as any that confront us—and as difficult. They are not only problems in physics, but problems in physiology—and, one might add, of psychology, when, for example, the two engines of an aeroplane get out of step, with a consequent production of "beats," a passenger is apt to think that the safety of the aeroplane is endangered. It appears that the sensation of sound varies only with the logarithm of the intensity, so that a million-fold reduction from the physical standpoint is felt as a reduction to one-sixth. This shows how enormous are the difficulties confronting us, if we would make a silent aeroplane.

WORK in preparation for the proposed new Trans-Atlantic telephone cable is now in progress on both sides of the Atlantic. At Stranraer, a survey has been made for a station, which, by an extension from Ayr, will be linked with the new telephone cable to be laid between Glasgow and Ayr. Designed in the first place to improve the cross-channel service with Ireland, this new line is likely to be a connecting link with the Ireland-Nova-Scotia trans-Atlantic cable. On the other side of the Atlantic the land-line which will connect New York with Nova Scotia has already been completed through Maine and part of New Brunswick. About £200,000 is to be spent in Nova Scotia for land connections with the new cable, and a Bill, introduced in the House of Assembly at Havre (N.S.) providing for the necessary rights of way, has been favourably received.

The Automatic Stabilisation of Ships.

No. VI.*

IN Fig. 18 we illustrate diagrammatically the application of a gyroscope to the hull of a ship. The disc spins on its axis inside a frame which is mounted to turn freely on an athwartship axis X X. It will be assumed for the time being that this axis X X passes accurately through the centre of gravity of the disc and frame—that is to say, that if the disc were not

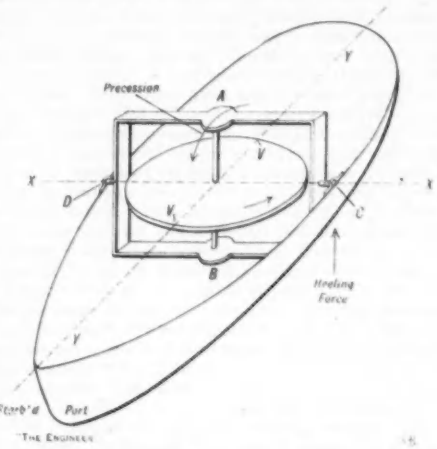

FIG. 18—ELEMENTARY GYROSCOPIC STABILISER

spinning, the equipment would be in neutral equilibrium. It will further be assumed that the initial position of the equipment—that is to say, the position occupied when the vessel is floating at rest on an even keel—is such that the axle A B is vertical.

It will be observed that if the vessel is turned on her course, the motion, if any, which the hull seeks to impose on the disc does not involve an effort to rotate it about a diametral axis. If the vessel pitches, the pitching moment can only be transmitted to the disc by virtue of the existence of friction at the gunwale bearings C D. If that friction is negligible, pitching of the vessel will apply no force acting to turn the disc about a diametral axis. Steering and pitching, therefore, will not cause the manifestation of any gyroscopic phenomenon in the disc. It is otherwise, however, as regards rolling. If the vessel is subjected to a heeling force acting, let us say, to roll her to starboard, a moment will be applied, through the gunwale bearings, the frame, and the axle, to the disc, and will act to turn the disc about a diametral axis coincident with the longitudinal axis Y Y of the ship. The effect will be, as we know, to set the gyroscope precessing about the transverse axis X X, the end A of the axle moving towards the bow of the ship, and to cause the gyroscope to develop a reaction in opposition to the heeling force.

Before we can examine the behaviour of the gyroscope in further detail, we must study the nature of the heeling moment applied by a train of waves to a ship exposed to their action. In Fig. 19 there is represented in cross section the hull of a *fully stabilised*

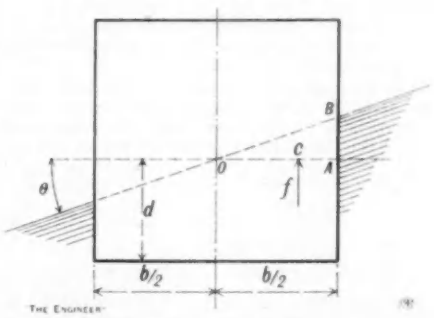

FIG. 19—HEELING MOMENT OF A WAVE

vessel on a wave, the surface inclination of which is θ. The actual hull form of the ship may be regarded as replaced by a rectangular block of length *l*, breadth *b*, and draught *d*. The buoyancy of the ship to the right of the centre line is in excess of that to the left by twice the weight of a volume of water having a triangular section O A B, and a length equal to the length *l* of the ship or equivalent block. This excess buoyancy will act to heel the vessel over to the left, and it may be regarded as a force *f* concentrated at two-thirds of the half breadth O A from O. Taking the weight of sea water at 64 lb. per cubic foot, the weight of the volume of water of section O A B and length *l* is—

$$64 \cdot \frac{1}{2} \cdot OA \cdot AB \cdot l = \frac{1}{2} 64\, l \frac{b}{2} \frac{b}{2} \tan\theta = \frac{1}{8} 64\, l\, b^2 \tan\theta.$$

The "arm" O C of this force is $\frac{2}{3}\frac{b}{2}$. Hence, the total

* No. V. appeared May 2nd.

heeling moment exerted by the wave on the ship is $\frac{1}{12}\,64\,l\,b^3\tan\theta$. The displacement w of the vessel is, however, given by $w=64\,l\,b\,d$. It follows therefore that the heeling moment can also be written as

$$\text{H.M.}=\frac{1}{12}\,\frac{w\,b^2}{d}\tan\theta.$$

It will be seen, then, that the heeling moment is the product of two terms, one, $\frac{1}{12}\,\frac{w\,b^2}{d}$, which is determined by the dimensions of the vessel, and is therefore constant except in so far as her state of loading may vary her draught and displacement, and another, $\tan\theta$, which is a function of the waves. The angle of slope θ of a wave varies from point to point on its profile. If the wave profile is assumed to be of sine form—more accurately, it should be taken as trochoidal—the value of $\tan\theta$ at any instant t is given by $\frac{\pi\,\text{H}}{\text{L}}\cos\frac{2\,\pi}{\text{T}}\,t$, where T is the period of the wave train, L the length from crest to crest, and H the height from crest to trough. It may here be noted for future reference that observation confirmed by theory shows that the length of a wave is very accurately related to its period by the expression $\text{T}=0{\cdot}44\,\sqrt{\text{L}}$. The ratio of the height to the length may be anything up to a maximum of one-third or thereabouts. A fair general average value of H/L is about 1/20. For purposes of comparison, it will be useful hereafter to refer to a typical or standard wave. To facilitate calculations, it is convenient to take the period at 6·2832 seconds ($=2\,\pi$), which, according to the rule quoted, implies that the length of the wave will be 204ft., or, in round numbers, 200ft. The height of the wave will be taken at one-twentieth of its length, or 10ft. This "standard" wave is greater than many commonly encountered, but is less than the maximum which a vessel must be prepared to meet.

We see, then, that the heeling moment experienced by a fully stabilised ship on a sine form wave is given by—

$$\text{H.M.}=\frac{1}{12}\,\frac{w\,b^2}{d}\cdot\frac{\pi\,\text{H}}{\text{L}}\cos\frac{2\,\pi}{\text{T}}\,t;$$

which, for brevity, may be written $\text{H.M.}=\text{K}\cos\text{B}t$. In Fig. 20, curve A represents the profile of a sine wave train. Curve B represents the corresponding heeling moments to which a *fully stabilised* vessel exposed to the train would be subjected. It is to be carefully noted that while the vessel is exposed to these heeling moments, she does not yield to them. Being by supposition fully stabilised—as, for example, by a gyroscopic equipment—she rides over the waves and maintains constantly a vertical position.

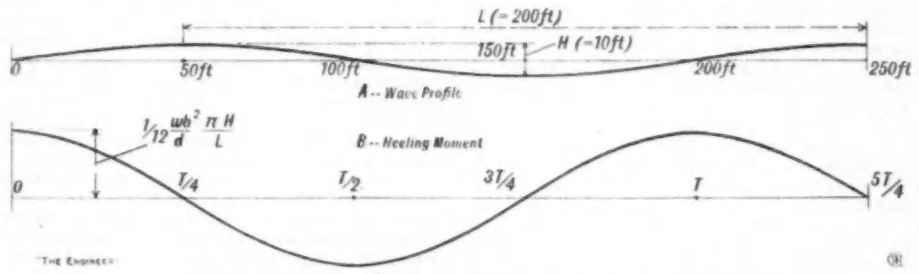

FIG. 20—WAVE PROFILE AND CURVE OF HEELING MOMENTS

It will be observed that the heeling moment has a maximum value at zero time, and again at time T, the period of the waves, that at T/2 it has an equal but oppositely directed maximum value, and that at T/4 and 3 T/4 it is zero. The maximum value of the heeling moment is clearly $\frac{1}{12}\,\frac{w\,b^2}{d}\cdot\frac{\pi\,\text{H}}{\text{L}}$. For purposes of arithmetical illustration, we may take a typical steamer as being equivalent to a rectangular block 310ft. in length, 30ft. in beam, and 15ft. in draught, the corresponding displacement being 4000 tons. The maximum heeling moment experienced by this typical vessel, if she were fully stabilised and were exposed to a train of waves having a height-to-length ratio of 1/20, would, then, be 3141 tons-feet ($=1000\,\pi$). On our standard wave in which H/L $=1/20$, and $\text{T}=2\,\pi$ seconds, the heeling moment at any instant t (in seconds) would therefore be given by $\text{H.M.}=3141\cos t$. In this formula $\cos t$ is to be taken as being the cosine of an angle of t radians. In Fig. 21 the typical vessel is drawn to scale on a standard wave. It will be noted that her beam of 30ft. occupies a considerable length of the quarter wave, and therefore that the construction shown in Fig. 19 in which the curved wave profile is regarded as replaced by the straight tangent to the profile must involve some inaccuracy. The error is not, however, of an order or of a kind which will affect our explanation of the principles of gyroscopic stabilisation.

Let us return now to the vessel equipped with a gyroscope, as shown in Fig. 18, and consider the effect produced on her when she is exposed to a regular train of waves producing the rhythmically varying and reversing heeling moments represented in Fig. 20. The initial or maximum heeling moment at zero time is $\frac{1}{12}\,\frac{w\,b^2}{d}\,\frac{\pi\,\text{H}}{\text{L}}$ or K, as we may write it for brevity. The gyroscope having a polar moment of inertia I and a rotary speed of $\dot{o}$, the precession $\dot{\phi}$ with which it begins its motion under the action of the initial heeling moment will, as we know, be given by $\dot{o}\,\dot{\phi}\,\text{I}/g=\text{K}$. A very short time after the precession has started the gyroscope will acquire some such position as that shown in Fig. 22. The heeling moment during this short interval falls from the maximum value K to, say, $\text{K}-k$—actually from K to $\text{K}\cos\frac{2\,\pi}{\text{T}}\,t$ or $\text{K}\cos\text{B}\,t$, as we may write it. This reduced moment acts, like the initial moment, about the longitudinal axis Y Y of the ship. At the outset of the motion the diameter V V of the disc was coincident with Y Y. At the end of the short interval we are considering the precession has tilted the diameter V V, which now lies at an angle φ, say, to Y Y. The full value of the reduced moment $\text{K}-k$ is applied about Y Y and not about V V. Its value about V V is, in fact, only $(\text{K}-k)\cos\varphi$. It is evident, therefore, that under the conditions specified the moment applied to the disc about its diametral axis V V is simultaneously affected by two causes acting to vary it: (*a*) the change in the heeling moment about Y Y, and (*b*) the change in the inclination φ of V V relatively to Y Y. During the first quarter period the heeling moment is progressively falling and the angle φ is increasing. Hence both causes are acting simultaneously to reduce the moment acting on the disc about its diameter V V.

The initial precessional velocity, as we have seen, is given by $\dot{\phi}=\text{K}\,g/\dot{o}\,\text{I}$. At the end of the brief time we are considering the moment acting about V V has fallen to $(\text{K}-k)\cos\varphi$. The corresponding precessional velocity is $\dot{\phi}'=(\text{K}-k)\cos\varphi\,g/\dot{o}\,\text{I}$; that is to say, it is less than the initial velocity $\dot{\phi}$. It is evident then that the change which has occurred in the moment about V V is not such as to *increase* the initial precessional velocity $\dot{\phi}$. Since, too, the gyroscope is by supposition in static equilibrium about the axis of precession, that is to say, since it is not counterweighted like a pendulum, the only influence present acting to *decrease* the initial precessional velocity is the frictional resistance at the athwartship journals. Neglecting this friction, therefore, we see that the initial precessional velocity $\dot{\phi}$ once acquired will persist. It will remain constant and therefore in any time t the angle φ through which the axle tilts away from the vertical will be given by $\dot{\phi}\,t$ or $\text{K}\,g\,t/\dot{o}\,\text{I}$.

Consider then the gyroscope precessing about the transverse axis with a constant velocity equal to the initial precessional velocity $\dot{\phi}$. The reaction couple about the axis V V will be $\frac{\dot{o}\,\dot{\phi}\,\text{I}}{g}$, and at any instant when the precessional tilt has the value φ the vertical component of this reaction couple will be $\frac{\dot{o}\,\dot{\phi}\,\text{I}}{g}\cos\varphi$. This vertical component acts about the longitudinal axis Y Y of the ship and is available to counteract the heeling moment instantaneously in existence. If, then, this vertical component is exactly equal to the heeling moment at each and every instant the ship will be fully stabilised.

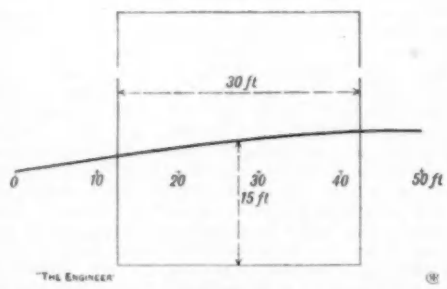

FIG. 21—TYPICAL VESSEL ON "STANDARD" WAVE

We have now obtained all the data required for a complete analysis of this elementary case of gyroscopic stabilisation. At any time t after the start of the precessional motion the precessional velocity of the gyroscope will be the constant initial velocity

$$\dot{\phi}=\text{K}\,g/\dot{o}\,\text{I}.$$

The angle of inclination of the diameter V V relatively to the longitudinal axis Y Y will be

$$\varphi=\dot{\phi}\,t=\text{K}\,g\,t/\dot{o}\,\text{I}.$$

The heeling moment in action on the vessel about Y Y will be

$$\text{H.M.}=\text{K}\cos\frac{2\,\pi}{\text{T}}\,t.$$

The vertical component of the gyroscopic reaction opposing the heeling moment will be

$$\text{V.C.}=\frac{\dot{o}\,\dot{\phi}\,\text{I}}{g}\cos\varphi=\frac{\dot{o}}{g}\cdot\frac{\text{K}\,g}{\dot{o}\,\text{I}}\cdot\text{I}\cos\frac{\text{K}\,g}{\dot{o}\,\text{I}}\cdot t$$
$$=\text{K}\cos\frac{\text{K}\,g}{\dot{o}\,\text{I}}\cdot t.$$

If, then, the vessel is to be completely stabilised—that is to say, if at every instant the vertical component of the gyroscopic reaction is to be exactly equal to the heeling moment—we must have

$$\text{K}\cos\frac{\text{K}\,g}{\dot{o}\,\text{I}}\cdot t=\text{K}\cos\frac{2\,\pi}{\text{T}}\cdot t$$

or

$$\frac{\text{K}\,g}{\dot{o}\,\text{I}}=\frac{2\,\pi}{\text{T}}.$$

This result establishes a critical relationship between the dimensions of the vessel, the size and speed of the gyroscope and the size and period of the waves. Subject to its being fulfilled, we see that the angle of tilt φ of the gyroscope at any instant t will be $\varphi=\frac{\text{K}\,g}{\dot{o}\,\text{I}}\cdot t=\frac{2\,\pi}{\text{T}}\cdot t$. Hence at the end of the first quarter period T/4 the angle of tilt will be $\frac{2\,\pi}{\text{T}}\cdot\frac{\text{T}}{4}=\frac{\pi}{2}$ $=90$ deg. At the end of the half period T/2 it will be 180 deg., at the end of the three-quarter period 3 T/4 it will be 270 deg., and at the end of the complete period it will be 360 deg. It is therefore clear that the gyroscope precesses continuously about the athwartship axis with a constant velocity $\dot{\phi}$ which is such that the gyroscope makes one complete turn in the period T of the waves. The reader can readily satisfy himself that continuous rotation at this rate will, in actual fact, completely stabilise the vessel. For example, at the end of the quarter period T/4 the axle is horizontal. The reaction couple corresponding to the constant precessional velocity $\dot{\phi}$ is equivalent to a horizontal force applied to the port bearing pushing it astern, and a similar force acting on the starboard bearing pushing it ahead. The reaction couple may therefore have an effect tending at this instant to turn the vessel off her course, but it has no component about the longitudinal axis. This is as it should be, for at this instant the heeling moment is zero. Again, at the half period T/2 the axle has precessed through 180 deg. In effect, therefore, the gyroscope is in the same condition as it was at the outset of the motion, except that it is upside down and therefore is rotating about its axle in the opposite direction. The reaction about the diametral axis V V momentarily coincident again with Y Y—is equal in amount to the initial reaction; that is to say, to the initial value of the heeling moment, but is reversed in direction. This again is as it should be, for at this instant the heeling moment has the initial value, but is acting in the opposite direction.

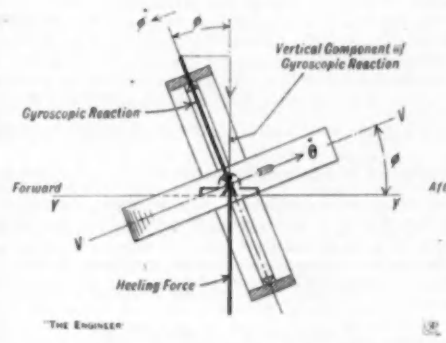

FIG. 22—ACTION OF GYROSCOPE

There is no structural reason why the gyroscope should not be allowed to precess with uniform angular velocity constantly in one direction. Subject therefore to the friction at the precessional journals being satisfactorily eliminated, it would appear that we have here a simple and direct method of completely stabilising a ship by means of a gyroscope. It is true that in the process of stabilising the vessel we would apply to her a varying gyroscopic couple acting to make her head swing to and fro about her course. This couple would reach its maximum value in alternate directions, when the axle was horizontal, that is, at the quarter and three-quarter periods when the vessel was on the crest and at the trough of the waves. It might prove objectionable. We need not, however, stop to examine it further, for there is a far greater objection to this elementary system of stabilisation.

Let us examine the significance of the critical

relationship $K g/\dot{\phi} I = 2\pi/T$, which, as we have seen, must be fulfilled under this system. Writing out the full value of K, we can re-state the relationship as—

$$\frac{g}{24} \cdot \frac{w b^2}{d} \cdot \frac{1}{\dot{\phi} I} = \frac{L}{H T}$$

For any given ship therefore—w, b, and d being fixed and unalterable—the gyroscopic factors $\dot{\phi}$ and I have to be made such as to bear to the wave factors L, H, and T the relationship specified by this equation. Once the gyroscope is installed, it is not practicable to vary its moment of inertia I. The only possible factor which might be varied is the speed $\dot{\phi}$. Some variation would definitely be required in this factor, for the quantity L/H T is not constant from one wave train to another. There is, as we have said, a certain relationship between the period T and the length L of sea waves. There is, however, none between the height H and the length L. An examination of published figures of observed wave dimensions shows that the quantity L/H T may range from about 1 to about 7. For our "standard" wave of period 6·28 sec., length 200ft., and height 20ft., it has the value 1·6.

It is possible to picture the speed of the gyroscope being altered to suit the magnitude of the waves encountered, but means for doing so in an automatic manner have never, so far as is known, been proposed. Difficulty would clearly arise in arranging to accelerate or decelerate the heavy quickly rotating fly-wheel without a considerable lag.

For the case of our typical ship on the standard wave, the critical relationship gives us $\dot{\phi} I = 100{,}500$ in tons, feet, and radians per second. Let us take it that the fly-wheel is a disc 2 R feet in diameter and R/2 feet in thickness. If it is of forged steel, it will have a mass of $\frac{1}{2} \times 490 \times \pi \times R^3$ pounds, and its polar moment of inertia will be $\frac{1}{4} 490\, \pi\, R^5$. Let us suppose that we limit its peripheral speed to 600ft. per second, corresponding to a centrifugal tensional stress in its outer skin of 17 tons per square inch.* Its angular velocity $\dot{\phi}$ in radians per second will then be 600/R. Hence the quantity $\dot{\phi} I$ for this wheel will be expressed by—

$$\frac{1}{4} 490\, \pi\, 600\, R^4 \div 2240 \div 105\, R^4$$

in tons, feet, and radians per second. Equating this to the required value 100,500, we find that R has to be about 5ft. 6in. The fly-wheel required to give the typical ship complete stabilisation on the standard wave would therefore have a diameter of 11ft., a thickness of 2ft. 9in., and a weight of about 58 tons. Its speed would be about 1040 r.p.m. If the magnitude of the waves decreased, the speed of rotation of the fly-wheel would in accordance with the suggested system of working be reduced, and there would be a consequent fall in the centrifugal tension in the wheel. If, however, the waves increased in magnitude, the increased speed required to give complete stabilisation would involve an increase in the centrifugal tension. For example, if the waves increased to twice the height of the standard wave, their period and length remaining unaltered, the speed of rotation of the fly-wheel would have to be raised from 1040 r.p.m. to 2080 r.p.m. As a consequence, the centrifugal tension would increase from 17 tons per square inch to 68 tons.

A centrifugal tension of 17 tons per square inch would not be considered safe by many engineers. If, however, we take it as being the maximum permissible figure, it is evident that the increase of speed required to give complete stabilisation on a wave of double the magnitude of the standard wave would involve a grave risk of the fly-wheel bursting. The fly-wheel must clearly be designed to suit the maximum, not the average, wave conditions. Taking the maximum magnitude of the waves as twice that of the standard wave, we find that if complete stabilisation is to be given when the maximum waves are encountered, and if the centrifugal tension then existing is not to exceed 17 tons per square inch, the wheel required would have a diameter of about 13ft., a thickness of about 3ft. 3in., and a weight of about 96 tons. Its speed to give complete stabilisation to the typical ship on the maximum waves would be about 875 r.p.m. Under the average conditions, represented by the standard wave, complete stabilisation would be given by adjusting the rotary speed of the fly-wheel down to 437 r.p.m. The centrifugal tension at this speed would be about 4¼ tons per square inch. The wheel required, it is therefore clear, would not only be large and heavy, but under average conditions would be stressed to an inefficiently low value.

It is obvious, then, that the plan of allowing the gyroscope to precess continuously in one direction with a constant speed and of adjusting the speed of spinning to suit the magnitude of the waves, presents several practical difficulties and objections. The alternative, as will be shown in the next article, is to preserve the speed of spinning constant and to restrict the precession to an arc short of a complete circle—to confine it, in fact, within the limits of ±90° from the initial vertical position. It will be shown that variation in the magnitude of the waves can be met in this arrangement by a variation of the amplitude of the swing within the limits mentioned, and that the control of the amplitude in the required manner lends itself to achievement by automatic means.

(To be continued.)

* For a steel wheel the centrifugal stress in tons per square inch is given by $f = V^2/21{,}200$, where V is the peripheral speed in feet per second.

Iron and Steel Institute.

No. I.

THE annual meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers, Great George-street, London, on Thursday and Friday, May 1st and 2nd.

Professor Henry Louis (President) was in the chair at the opening of the meeting on Thursday, May 1st, and a warm welcome was given by the members to Monsieur de Fleuriau, the French Ambassador, who had attended as a mark of appreciation of the presentation that was to be made of the Bessemer Medal to his countryman, Monsieur Eugene Schneider.

The report of the Council was taken as read and adopted without discussion. The report states that—

During the past year one hundred and ten new members and eleven associates were elected; six associates were transferred to membership and six members were reinstated. Forty-seven members resigned their membership during the year and the names of twenty-six members were removed from the register owing to the non-payment of their subscriptions. The total membership of the Institute on the register on December 31st, 1929, was 2022, showing an increase of fourteen.

The income for the year under review, apart from that of the Carnegie Scholarship Fund and of the Special Purposes Fund, was £7974, and the expenditure was £8123. It is a matter of concern that the Council again have to record an adverse balance in the accounts, the principal reason being, as in past years, that while the income remains practically stationary the expenditure continues gradually to increase, due to the various activities of the Institute and the heavy cost of publications.

Sir Harold Carpenter, F.R.S., hon. treasurer, then presented the annual accounts, which were also adopted without discussion. Sir Harold said that, although at the last annual meeting he had been able to report a small credit balance, on the present occasion, owing to the heavy cost of the Autumn Meeting, there was a small deficit, the Autumn Meeting having cost £329 as against only £12 in the previous year. There were signs, however, which encouraged him to hope that the difficulties with which the Institute had had to contend for nine years were being gradually overcome, and that the financial position would soon be more stabilised than it had been for some years. As regards exemption from payment of income tax on its funds, the Council was taking legal advice, and it was hoped to bring that matter to a successful issue and to obtain a restoration of the privilege that was abrogated four years ago. The Institute had been able to obtain exemption from payment of local rates. The tendency towards a decline in the number of new members, to which he had referred two years ago, had ceased, and the accounts showed that the receipts from subscriptions had increased during the past two years. The total expenditure now was £600 per annum less than it was two years ago, and although this saving had been more than offset by increases in other directions, he thought the general position could be regarded as satisfactory.

The meeting then confirmed an amendment in By-law 10, providing that the President shall be elected for two years instead of one, but shall not be eligible for re-election until after an interval.

Under this by-law, Professor Henry Louis will continue as President for a further twelve months.

The President then presented the Bessemer Medals to Monsieur Eugene Schneider and to Dr. Walter Rosenhain, F.R.S., and said that the Council of the Institute this year had before it the names of two gentlemen who were so admirably qualified to receive the Bessemer Medal that it found itself in the position of being unable to prefer either of them to the other, and therefore decided to confer the Medal upon both. That course had been adopted on only a few previous occasions. The Medal was instituted in 1874, and during the fifty-seven years which had since passed, two Medals had been awarded simultaneously on five occasions. Monsieur Schneider, continued the President, was President of the Institute in 1918 to 1920, and was, of course, the head of the famous firm of Le Creusot, founded in 1800 by his grandfather. Monsieur Schneider's father, Monsieur Henri Schneider, who succeeded in due course to the control of the firm, was awarded the Bessemer Medal in 1889, that being also one of the exceptional occasions on which two Medals were awarded in the same year. Desirous as we all were that the terrible years of the Great War should speedily be forgotten, it was, nevertheless, impossible to mention the names of Schneider or Le Creusot without alluding to the great services which the firm had rendered in furnishing the French Army with artillery. Whilst we all recognised the importance of the man behind the gun, it was only right that due share of the credit should be given to the man who made the gun, and the services of Monsieur Schneider and his firm stood out very prominently in that connection. Of recent years Monsieur Schneider had not confined his activities to Le Creusot, but had also acquired controlling interests in other metallurgical works, prominent among which was the Skoda works in Czechoslovakia. In his capacity as head of these various important metallurgical establishments, Monsieur Eugene Schneider had contributed very largely to the advancement of the metallurgy of iron and steel, and was therefore eminently fitted to become a recipient of the Bessemer Medal. The present was only the second example of father and son both being recipients of the Bessemer Medal, the other instance being that of Sir Hugh Bell and his distinguished father.

The Medal was then handed to Monsieur Schneider, who was given a cordial reception.

Monsieur Schneider expressed his appreciation of the honour conferred upon him in being awarded the Bessemer Gold Medal, and referred with pride to his term of office as President ten years ago. He added that he was the happier in receiving the Medal because his name had been associated in the award with that of his friend Dr. Rosenhain. The Institute by making this double award on the present occasion had honoured science and industry, the close alliance of which in the iron and steel industry had proved so fruitful and so indispensable to the enormous developments of recent years. The hand-in-hand work of industry and science had greatly benefited by the activities of the Institute. In conclusion, Monsieur Schneider expressed his personal thanks to the French Ambassador for having attended the meeting.

Monsieur de Fleuriau, in a few words expressing his pleasure at being present, recalled that he had represented Monsieur Cambon at the Institute in 1915, when the Bessemer Medal was awarded to another of his countrymen, Monsieur Pierre Martin.

The President, continuing, said that the other Bessemer medallist, Dr. Walter Rosenhain, was too well known to need any introduction to members of the Iron and Steel Institute. He came to this country in 1897 from his birth-place in Australia, as an 1851 Research Scholar, and promptly devoted himself to metallographic work with such marked success that in 1899 he published with Sir Alfred Ewing the famous joint paper announcing their discovery of the "slip bands" in metals that underwent mechanical deformation. Since that time, Dr. Rosenhain had done an enormous amount of research work among metals, especially on behalf of the Alloys and Iron Research Committee, and had contributed to scientific and technical societies numerous papers dealing mainly with the micro-structure and physics of metals. In 1906 he was appointed Director of the then newly established Department of Metallurgy in the National Physical Laboratory. He commenced his work there with a staff of four, but had so increased his sphere of operations that to-day he had no less than seventy workers under his direction. The Iron and Steel Institute had every reason to be grateful to Dr. Rosenhain for the work he had done and for the light he had thrown upon so many of the more obscure phenomena of iron and steel manufacture, and perhaps, above all, for so freely communicating to the members of the Institute results of his researches.

Dr. Rosenhain said that it was difficult adequately to express his appreciation at being awarded the Bessemer Gold Medal, but he was bound to say that it must be regarded as a recognition more of the work of leadership of a group of able and enthusiastic workers rather than individual work of his own, because it would have been impossible to carry out the work that was done at the N.P.L. without the splendid group of men, who, although they had changed from time to time, had assisted in the development of the Metallurgical Department of the N.P.L. during the last twenty-four years. Many of them were still with him, but others had gone to occupy posts of high importance elsewhere in the country. He thought it could be said of himself and his colleagues that they not only frequently provided food for criticism at the meetings of the Institute, but they also frequently provided the criticism, and, in again expressing his high appreciation of the great honour that had been done him, he could only hope that his colleagues and himself would be able to continue to provide both in the future.

The reading and discussion of papers was then proceeded with.

The first paper read was one by Professor W. A. Bone, F.R.S., and Drs. L. Reeve and H. L. Saunders on "An Experimental Inquiry into the Interaction of Gases and Ore in the Blast-furnace."

BLAST-FURNACE RESEARCH.

This paper is a continuation of one printed in the *Journal* of the Institute in 1927. The principal new results described may be conveniently summarised as follows:—(1) Carbon deposition, due to the reversible reaction $2CO \rightleftarrows C + CO_2$, begins at quite low temperatures—for instance, slowly at 275 deg. Cent.—and its optimum temperature is about 450 deg. Cent.; it is, however, a catalytic phenomenon, in the sense that it does not occur in the absence of a suitable catalysing surface. Iron Fe_3O_4 and FeO are all powerful promoters of carbon deposition at temperatures up to between 650 deg. and 700 deg. Cent., and round about the optimum temperature there appears to be no limit to its progress. At higher temperatures, however, the phenomenon becomes inappreciable until nearly 90 per cent. of the possible ore reduction has been completed, when it again becomes prominent.

(2) Such carbon deposition in the blast-furnace at temperatures between 275 deg. and 700 deg. Cent. may result in either or both a carbon impregnation and/or a carbon envelopment of the ore granules, the former being beneficial to ore reduction but the latter scarcely so.

(3) The carbon deposited in the pores and interstices of carbon-impregnated ore granules is a much more powerful ore reducer than carbonic oxide at 750 deg. Cent.

(4) Carbide formation, if any, seems always to be conditioned

by the presence of free iron in a system containing both oxides of carbon and an ore undergoing reduction.

(5) Determinations of CO/CO_2 equilibrium ratios in the systems $Fe_3O_4+CO \gtrless 3FeO+CO_2$ and $FeO+CO \gtrless Fe+CO_2$ have been made at temperatures of 750 deg., 850 deg. and 975 deg. Cent., with results very closely agreeing with those previously obtained by Matsubara.

(6) Measurements have been made of the rate of approach to equilibrium over the 30 to 65 per cent. ore reduction range using the two ores A and B, and they indicate that ore B is more readily reduced than ore A.

(7) Sintering occurs when charges of partially reduced ores are maintained for considerable periods at temperatures above 750 deg. Cent.

(8) A special apparatus has been devised to permit of the detailed study of relative reaction velocities between blast-furnace gases of any given composition and iron ores at all stages of reduction, at all temperatures up to 1200 deg. Cent., and provision has been made for the determination of the extent to which variations in the speed of gas flow over the ore surface at rates comparable with those obtaining in the blast-furnace influences these reaction velocities.

In introducing the paper, Professor Bone asked if the members of the Institute were really interested in a work of this kind. He did not, he said, imply that they were not, but the reason he asked the question was that three years ago, when he read the first paper on the subject, he had extended an invitation to all those interested in blast-furnace problems to come to the laboratory and see the work that was being done and discuss it. At the same time, he had offered to go to any provincial meeting of the Institute and discuss the work in detail and receive criticism of it. As a matter of fact, apart from a small group of blast-furnace chemists, who had come one afternoon, there had only been three people who had been sufficiently interested to go to the laboratory during the past three years. He, therefore, wished to repeat the invitation, and hoped that those interested would avail themselves of it, because the work to be done was essentially such as should be done jointly in the laboratory and in the works. For instance, there must be more co-operation than had hitherto existed with blast-furnace people on the question of ascertaining data not only as to the composition of gases, but data as to the material in the furnace at different temperatures, because until those data were obtained they were largely talking in the air as to the application to blast-furnace practice of the scientific results obtained in the laboratory. We wanted data as to the smelting of British ores under standard conditions, corresponding to the work done in America. At present, there were no British data, and it was necessary to take the American data which, however, only applied to American conditions.

Mr. Fred Clements, chairman of the committee under which Professor Bone is carrying out this work, said that the paper could only be regarded as an interim report. There was one feature, however, of the greatest importance which had been brought out in it, and that was that carbon deposition occurred in the two different ways, namely, by envelopment and impregnation. The phenomena of carbon impregnation had never been emphasised before, and it seemed to account for many of the results which were found in actual practice. An important question which arose, however, was whether carbon impregnation would penetrate far into a lump of ore. One could hardly imagine that it would, but it was a question which would have to be answered. In the authors' experiments the granules used were relatively small and the distance of the farthest molecule of iron oxide from the surface of contact would not be more than $^1/_{20}$in. Therefore, he wondered if the impregnation of carbon, which was admittedly of importance, would take place within a lump of commercial ore to a degree that would mean its effective reaction upon the mass. The reaction which Professor Bone had obtained at the higher temperatures was largely the result of using a blast-furnace gas mixture with 100 per cent. content of CO_2 but that condition would hardly exist within the furnace itself. Therefore, although it was only conjecture on his part, he was rather of the opinion that the major reaction of reduction was between CO and iron oxide direct, rather than through the medium of impregnated carbon. That, however, was a point still to be proved by experiment. Another important feature which arose was the influence that impregnated carbon had on the disintegration of the ore. Some time ago, he was called in a hurry to an emergency condition in a neighbouring works and found that a very heavy slip had taken place. Fortunately, the furnace had been tapped, otherwise, a serious personal disaster might have happened. The whole of the material was spread round the furnace within a radius of some 30 yards, and he did not find 1 per cent. of the pieces bigger than his thumb. He could not imagine, however, that all that crushing had been done by the explosion, and it seemed to indicate that the disintegration of the ore and of the coke went on within the furnace itself to a degree which was not normally suspected. It was clear, concluded Mr. Clements, that in this matter we are living on the edge of an unknown continent, and that a great deal of work yet remained to be done.

Professor H. E. Armstrong, F.R.S., said that it was a remarkable admission that the industry was living on the edge of an unknown continent, but, undoubtedly, that was the case. Mr. Clements had brought out, lucidly, numerous points on which a surprising amount of ignorance existed. Professor Bone had clearly indicated that a special type of carbon was being formed and some new name was required to distinguish it. Until we got into our minds that it was not elementary carbon, we were being misled. The work being done was of fundamental importance, and apart from his own technical interest in the industry he happened to be a very large shareholder in iron and steel, and would like to see some return on his money. Steel was being used all over the place and yet there were no dividends to the shareholders, and he regarded that as a disgrace to the industry. Why was it that a material which was being more used than any other for constructional purposes was not paying? It meant that we were not using our coal and iron ores properly, that there was no science, in the proper sense of the term, behind either industry. There certainly was not behind the coal industry, and a great scientific effort was needed on behalf of those two industries to bring them into closer and more satisfactory co-operation. All recent discussions on coal seemed to have left iron out of account. His own view was that the carbon mentioned in the paper was probably incompletely formed graphite, possibly uncrystallised graphite, and he was further inclined to think that it was a compound of diamond and another kind of carbon which gave a very complex and remarkable structure.

Mr. E. C. Evans (National Federation of Iron and Steel Manufacturers) said that the time of from 1·5 to 4·5 seconds which the gas was in the furnace, did not represent the actual time that it was in contact with the ore, because the ore occupied only 30 to 40 per cent. of the volume of the furnace, and, therefore, those figures would be reduced quite considerably. Recently, through the courtesy of friends on the Continent and in the United States, it had been possible to get complete operating results from 180 furnaces which were rather interesting in that they showed that, apparently, each particular ore had its own time of contact, and that was probably one of the most important points with which the authors were dealing.

Mr. H. E. Wright said that the whole problem of making iron in the blast-furnace depended on reducing that iron with the least possible coke consumption, and the work of the authors was bringing us a little nearer to an understanding of the reactions that produced carbonic acid during a reduction of the iron. If we could reduce the iron without carbonic acid, practically the whole of the heat absorbed in the reduction of the iron would be supplied by the oxidation. Various ores had various reducibilities in the furnace and some were more suitable to a particular furnace than others. Some further light on that aspect would be extremely valuable.

Mr. R. A. Hacking, speaking with regard to carbon deposition, suggested that the results in the paper were really an exaggeration of what would obtain in actual practice, although, at the same time, they indicated what could be done in that direction when the opportunity offered was favourable. Professor Bone had commenced with 100 per cent. CO, and although the results might be regarded as more or less accurate at 850 deg. Cent., they were exaggerated at 450 deg. Cent.

The President said that although we had had a picture put before us of our ignorance of blast-furnace reactions, those who, like himself, could look back for half a century, knew that there had been enormous progress. In the early days it would have been impossible to find anyone connected with blast-furnace practice who had any knowledge at all of chemistry. They were mostly mechanics and sometimes only skilled labourers, and certainly not one of them could have understood this paper. He hoped, however, that the authors would continue their work.

Professor Bone, who will reply fully in writing, said that as there might be some misapprehension with regard to the 100 per cent. CO, he must point out that, although he commenced with that, he ended up with equilibrium after passing through every proportion of CO to CO_2, so that he could not see how that criticism of Mr. Hacking could really arise. Furthermore, the gas taken out of the furnace was not the gas in the interstices of the ore; it was a very complicated resultant. As to whether carbon impregnation took place or not—a point raised by Mr. Clements—as the iron reduced was in the centre of the ore, something had got to reach that point, and it must be CO, otherwise the ore would not be reduced. That being so, carbon deposition could take place as easily in the centre as on the outside.

The next paper read in the morning session was "Developments in Fuel Economy at Skinningrove," by Mr. F. Bainbridge.

FUEL ECONOMY AT SKINNINGROVE.

It is a comparatively simple matter to obtain fuel economy by high capital expenditure on new plant, but up to the present the management have been fully employed in making improvements which have involved only small capital outlay. For example, it has not seemed expedient to replace steam blowing engines, which are nearly fifty years old and which are extremely inefficient, until all the gas at present available has been employed to its maximum advantage.

Following the general strike, a thorough survey of the conditions prevailing in American and continental practice was made by the present management at Skinningrove in their efforts to devise ways and means to secure the desired fuel economy.

The problem to be examined by the management at the recommencement of operations in 1927 was how best to effect the maximum fuel economy with a limited capital expenditure. It was obvious that, before fuel economies could be obtained on the steel plant, it was essential to increase the volume of surplus gas at the blast-furnaces by reducing the possibility of wastage. Continental methods, such as large gas reservoirs, &c., did not seem the cheapest method of stabilising the gas pressure, and up to the present it has not been possible to tackle the cleaning of all the blast-furnace gas. The alternative, therefore, was to adopt such means as would admit of a saving of gas by a more economic combustion of the uncleaned gas in stoves and boilers, and provide sufficient cleaning plant to deal with the addition to the surplus gas before its application in the steel works.

The method of attack for this problem was obviously, then, some type of burner which would permit of:—

(1) The most efficient mixing of gas and air.

(2) Control of the air admitted, to secure as nearly as possible the theoretical proportion of air required by the gas under such conditions of pressure fluctuations as were prevailing at the time.

(3) Variation within limits of the type of flame with regard to intensity.

(4) No moving parts or direction vanes in the line of the gas stream to become choked with dust.

(5) A common air regulator for all stoves or groups of stoves, with ability to regulate each burner if desired.

(6) Minimum expenditure.

(7) Minimum personal supervision.

An examination of a large number of modern types of gas burner on the above lines ruled out all but a few, and these fell short on account of the cost of installation, and a burner was designed by the works manager, Mr. T. A. Mills, in collaboration with Mr. W. S. B. Bosanquet, which has since proved highly satisfactory under the conditions mentioned. The burner was constructed on the works and tried out on a specially built experimental furnace; it gave such promise that a second was built, differing slightly in design, and fitted to the same experimental furnace. Details of this burner are given.

The results obtained with the first of the stove burners, together with tests on the experimental furnace, indicated that this type of burner might be applied profitably to the main boiler range, particularly in view of the fact that it was possible to obtain complete combustion within about 5ft. of the burner orifice, the resultant flame being in a condition of extreme turbulence. Burners have therefore been fitted to seven of the thirteen boilers constituting the main boiler range.

A consideration of the coke oven gas supply indicated that, in addition to the amount being consumed by the soaking pits and wash heater, there should be, with careful regulation, a further surplus available for use in the melting shop, although, in the past, this supply had been too spasmodic and irregular for satisfactory continuous application. Further, the conversion of another of the soaking pits to both gas and air regeneration during the strike permitted the use of blast-furnace gas only, with a further liberation of coke oven gas for use elsewhere.

An attempt was made to feed a supply of coke oven gas into the slag pocket of one of the open-hearth furnaces, just below the gas uptake, but this did not permit of satisfactory manipulation, and results were erratic. The necessity for some means of supplying the gas direct to the hearth of the furnace was apparent, and, after several attempts, suitable water-cooled burners were devised, which fed the gas into the mouth of the main gas port, the burners entering on either side of the mouth at such an angle as to cause the coke oven gas to mix with the lower part of the producer gas stream whilst still being considerably blanketed from the roof by the upper part of the same stream.

In order to secure the full benefit from the available gas methods of control were instituted by the provision in the first place of a suitable electric recorder and a series of diaphragms, which would permit of its use on any one of the main gas conduits. This proved entirely satisfactory, but the need was soon felt for simultaneous readings on all mains, and experiments were carried out to determine a suitable formula for orifice plate readings, with the result that a series of simple differential gauges throughout all clean gas systems has been established.

Mr. W. J. Brooke, in opening the discussion, said that at Scunthorpe they had, for more than three years, been going into the whole question of fuel economy and heat conservation and had now prepared a scheme which it was hoped to put into operation very shortly. In his own case it was proposed to put in a large waterless gasholder having a capacity of two million cubic feet to deal with the blast-furnace gas, which gas would also be cleaned for gas engine purposes by a Thyssen cleaner. He preferred that to the author's pressure control system, ingenious though it was. Further, they had been experimenting at week-ends in the making of steel with blast-furnace coke and they had tried every possible method of mixing the gases together. He had, however, come to the definite conclusion that the system proposed in the present paper was not by any means the best, and he believed that better results would be obtained by passing the blast-furnace and coke-oven gas together through the regenerator, as that course resulted in a reduction of the time necessary in the steel furnace, thus bringing down the cost very considerably. His chief trouble at the moment was that his coke ovens were hopelessly out of date and that he had only 15 to 16 per cent. of surplus gas available, so that he could not do very much except at week-ends. It was hoped, however, eventually to get a considerable reduction in the amount of coke used per ton of pig iron. The Lincolnshire ore was very poor and involved the use of a large amount of coke. Undoubtedly, much gas had been wasted in the past, and one of the chief objects of the experimental work that had been done during the past three years was to measure carefully the amount of gas being used in every department of the works with a view to eliminating much of the waste. A new type of burner had also resulted in a very large saving of gas, and he looked forward to considerable savings, although at the moment the actual amount of coal used per ton of finished steel was 5¼ cwt.

Professor W. A. Bone asked the Skinningrove management why they did not get rid of their fifty-years-old steam engines and put in modern ones. One point of a general nature was that he wondered if people dealing with blast-furnace gas were really applying the work that was being done in many laboratories on carbonic oxide and combustion. As he read the papers, he felt that those concerned with the works could not be reading the scientific work at all, and he impressed upon them that it was almost criminal to burn carbonic oxide at all. It was a wonderful gas, and it was only because a commercial use could not be found for many of the products that could be produced from it that it was burned at all.

Mr. J. Henderson also disagreed with the policy

adopted at Skinningrove of not adapting gasholders for gas pressure regulation, his experience being that they are of considerable value. Although, in his own case, he had not yet been able to get out actual figures of economy as a result of using gasholders, it had been demonstrated in Germany that 8 per cent. was possible.

Mr. T. M. Service asked what was the average composition of the blast-furnace gas and the coke-oven gas and also what was the kilogramme per calorie per cubic metre of the gas used at the various places? Such low figures of the heat required to melt a ton of steel were given in the paper that people who were using 4½ cwt. to 5 cwt. per ton would have to consider the matter very carefully.

Mr. Benjamin Talbot said that the total coal per ton of finished steel at the Cargo Fleet Works was a little better than that mentioned in the paper, but they had not yet reached the stage where a ton of finished steel was made without any outside fuel.

Mr. D. Sillars regarded the gasholder as a counsel of perfection and suggested that it was not really imperative to have one. He took it that at Skinningrove the air was regulated to the gas, but it was also possible to regulate the gas to the air and in that way it was possible to maintain a steady pressure. Indeed, it was possible then to obtain many advantages over the gasholder.

Mr. Stottman (Sheffield) said that many fuel engineers in iron and steel works were faced with the problem of achieving fuel economies, not by replacing the coal with some waste gas, but by finding some more efficient way of applying the heat available. He anticipated that within the next few years there would be considerable development of the utilisation of coke-oven gas.

The President, in asking the author to reply in writing and, at the same time, inviting further contributions to the discussion in writing, said that he looked upon the paper as the first reply of the iron industry to the Coal Bill. It was a very effective reply, and he had not the least doubt that there were several other replies of the same tenour to come.

(To be continued.)

The East England Electricity Scheme.

As far as preparing electricity schemes is concerned, the task of the Electricity Commissioners is now practically complete. The eighth scheme, relating to East England, dealing with an area of about 3438 miles and covering practically the whole of the counties of Norfolk and Suffolk, has now been issued. Of the eight schemes that have been prepared six have now been adopted, and it is hoped that the seventh, covering South-West England and South Wales, will be adopted by the Board at an early date. The whole of England and Wales has now been covered, but there are certain sparsely populated areas in southern and northern Scotland that remain to be dealt with. The population in those areas, however, only represents a very small percentage of the whole population in Great Britain and the demand for electricity must be relatively small.

A considerable portion of the area covered by the East England scheme has hitherto been without a supply of electricity, and during 1928–29 the consumption per head of population was 61 units. It is estimated, however, that, in 1937–38 it will increase to 206 units. At present there are in the area 18 authorised undertakers owning between them 11 public generating stations, and, under the proposals, two of the existing stations, namely, the South Denes station of the Great Yarmouth Corporation and the Thorpe station of the Norwich Corporation, will be selected and operated for the Board. If necessary, the station of King's Lynn Corporation will be operated under temporary arrangements.

In providing for future demands in the area, it is contemplated that the base load output will be allocated, as far as possible, to the selected station at Great Yarmouth, because the cost of coal delivered to that station is less than that delivered to the Thorpe station. The remaining requirements will be met from the latter station and possibly in time by means of electricity from the area of the neighbouring scheme. The main purposes of the transmission system provided for by the scheme are (1) to enable the selected and other generating stations included in the scheme to be operated on account of the Central Board under arrangements made with the respective owners to their mutual advantage and for the benefit of the whole area; (2) to place the Central Board in a position readily to afford direct or indirect supplies of electricity to authorised undertakers within the area of the scheme, and (3) to enable the benefits of electricity supplies to be extended to new and undeveloped districts by the erection of secondary transmission lines, where necessary, by the municipal and company undertakers concerned, thus facilitating the establishment of distribution networks in those areas. The scheme provides for about 131 circuit miles of overhead primary transmission lines to be operated at a pressure of 132,000 volts between phases, the carrying capacity of each primary line covered by the estimates being not less than 50,000 kW. There will be four transforming stations. The lines will join up with the main transmission lines, for which provision was made in the South-East England scheme, thus forming a ring main and, consequently, giving greater security against breakdown, both in this area and outside it.

There will also be a short length of secondary transmission lines which will involve the provision of two other transforming stations. By 1937–38, the interconnection of the generating stations will result in releasing for revenue-earning purposes about 22,580 kW of spare plant, representing a sum of about £383,860. The cost of the scheme to the Board for the erection of the transmission system is estimated at £594,328, and in addition there will be an expenditure by undertakers of about £306,074 on extensions of existing stations. It is estimated that the full advantage of the scheme can be secured with a distinct saving on capital expenditure that would be necessary if the present system were continued and this saving of capital will be progressive.

The Commissioners have outlined a provisional plan of working the stations with the necessary estimates. The suggestions are, of course, tentative, since the working of the scheme, including the fixing of tariffs, is the responsibility of the Board, but the Commissioners estimate that in five years, *i.e.*, 1933–1938, there will be a saving to the undertakers in the area of about £218,578.

Books of Reference.

The Year Book of the Scientific and Learned Societies of Great Britain: A Record of the Work Done in Science, Literature and Art during the Session 1928–29 *by Numerous Societies and Government Institutions.* London: Charles Griffin and Co., Ltd., 42, Drury-lane, W.C. 2. Price 18s.—In the preface to last year's issue of this valuable book of reference, a special appeal was made to societies to order the book, and so make its continued publication in its then form possible. Unhappily, so we are informed in the preface to this year's—the forty-sixth—annual volume, the appeal produced a very meagre result, and the publishers announce that, unless the unforeseen happens, it is likely to be the last complete issue. For ourselves, we shall be very sorry, indeed, if publication ceases, for we have frequent cause to consult the volume, and never that we can remember have we failed to find the information that we sought.

The Empire Municipal Directory and Year Book, 1930–31." London: The Sanitary Publishing Company, Ltd., 8, Breams-buildings, E.C. 4. Price 12s. 6d. net.—For this year's issue of this extremely useful book of reference, the "Foreword" has been written by Professor R. G. H. Clements, M.C., M. Inst. C.E., who is professor of Highway Engineering at London University. The volume follows in its arrangement the same lines as those of preceding issues. There is, first of all, the "Directory of Local Authorities and their Officials," which is unique in that there is, to the best of our belief, nothing else in existence which approaches it in completeness. Section II. is devoted to "Road Construction and Maintenance"; Section III. to "Plain and Reinforced Concrete and Cement"; Section IV. to "Lighting, Heating and Ventilation"; Section V. to "Municipal Motor Transport"; Section VI. to "Water Supply, Purification and Softening"; Section VII. to "Sewerage and Sewage Disposal"; Section VIII. to "Public Cleansing and Waste Utilisation"; Section IX. to "Fire Prevention"; Section X. to "Housing and Town Planning"; Section XI. to "Labour-Aiding Plant and Appliances"; Section XII. to "Public Recreation Grounds"; Section XIII. to "Municipal and Public Health Law"; and Section XIV. to "Municipal Engineering, Public Health and Scientific Societies." In many of these sections, the history of the past year in the particular subject dealt with is included, and in all of them a great deal of new and interesting matter is given. Finally, Section XV. is a "Buyers' Guide" to machinery, plant, materials and supplies for municipal requirements, and after it comes a week-to-the-page diary.

Reid's Handy Colliery Guide and Directory for the Counties of Northumberland, Durham, Yorkshire, Cumberland and Westmorland. Published by Andrew Reid and Co., Ltd., Newcastle-upon-Tyne. Price 2s. 6d.—This book aims at giving in concise form such information as will be of service to those whose time is too limited to allow of their referring to the various authorities on the subjects they desire to study. It contains lists of colliery owners, collieries, agents, managers, and engines in the counties with which it specially deals, and a great deal of data concerning collieries, their output, management, &c. There are also included a couple of fairly large scale maps, one of them giving the position of collieries and railways in Northumberland and Durham, and the other doing the same for Yorkshire. Included, too, are the Coal Mines Act of 1911, with the various statutory rules and orders which have been issued since that Act came into force, and a collection of data likely to be useful to those engaged, directly or indirectly, with the coal mining industry.

The Water Engineer's Handbook and Directory, 1930. Published by *Water and Water Engineering,* 30 and 31, Furnival-street, Holborn, London, E.C. 4. Price 8s. 6d.—This is the second edition of this handy and useful little volume. In it several new features have been introduced, while the technical sections have been completely revised and substantially extended. The first section is devoted to "Water Engineering in 1929," and it contains an interesting summary of the extraordinary meteorological conditions experienced during the year and a brief review of the progress made in Water-works Engineering during the same period. Subsequent sections are concerned with:—"Water Laws"; "Pumping Machinery for Waterworks"; "The Purification of Water," and "Hydraulic Data and Formulæ." Then there is a list of Water Engineers and the Authorities to which they belong, which is followed by a directory of Water Undertakings in England, Wales, Scotland and Ireland, which gives the names of the Chief Officers, the area supplied, the source of supply, &c. Then come a section containing "Waterworks Statistics," another dealing with water undertakings in Australia, New Zealand, Canada and South Africa, and finally one giving particulars of Institutions and Government Departments.

The Colliery Year Book and Coal Trades Directory, 1930." London: The Louis Cassier Company, Ltd., 22, Henrietta-street, Covent Garden, W.C. 2.—This book—now in its eighth year of publication—contains a vast amount of information regarding collieries and the coal trade generally, and in its present edition it closely resembles its precursors, with the subject matter brought up to date. It is pointed out in the preface that, at the time of going to press—in March last—the coal mining industry was, figuratively speaking, "in the melting pot," and that until the Bill then under consideration in Parliament was passed, it was impossible to forecast what the position would be in in the succeeding six months. No attempt is therefore, made to do so. A comprehenaive review of the coal mining industry during 1929 is included, and it is pointed out that many more amalgamations took place place during the year and that a summary of them is given so that readers may obtain a bird's-eye view, as it were, of the position to date. The features of former issues have been included in the present volume, and an innovation is the insertion of a list of all the Low-Temperature Carbonisation Companies, together with particulars as to the processes employed.

The "Electrician" Annual Tables of Electricity Undertakings, 1930. Published by Ernest Benn, Ltd., Bouverie House, 154, Fleet-street, London, E.C. 4. Price 10s.—There is no need for any detailed introduction from us to this most useful volume, seeing that it is now in its 43rd year of issue. We may say, however, that it claims, we believe with reason, to furnish the most complete available record of Electricity Undertakings in the British Empire and in other countries throughout the world. The present issue contains particulars of no less than 800 British and 1300 Dominion, Colonial, American and foreign undertakings of all kinds. A new feature is a section giving details of British Electric Railways, which have now assumed considerable importance. The information throughout the book has been, we are informed, most carefully revised, details of all pre-existing undertakings having been brought up to date, whilst particulars relating to new undertakings and the progress made with projected schemes right up to the time of going to press, have been included.

SIXTY YEARS AGO.

ALTHOUGH we search in vain in our issue of May 13th, 1870, for any sign of the storm which was soon to burst over Continental Europe, we can detect indications in our pages that all was not well with France. There were rumours of a plot to assassinate the Emperor Napoleon. Many Frenchmen had questioned the reality of the alleged discoveries that had been made, but we assured our readers that no doubt existed that bombs suitable for the purpose had been made and that some of the missiles were even then in the hands of the Paris police. We went further and actually illustrated and described one of these nefarious appliances. It was a device curious in its design and in its manufacture. Two cast iron recessed discs, 5in. or 6in. in diameter, were held together by means of a central bolt. Lying loosely between the discs were four glass tubes containing a fulminate or picrate explosive. Round the periphery of the discs were eighteen radial holes, through each of which a common nail was inserted. These spines, on striking a hard body, would break the glass tubes and detonate the explosive. The construction was curious because of the evident danger to which it exposed anyone handling the bomb and because of the fine workmanship displayed in the manufacture of the cast iron shells and the crudeness of the rest of the work. We reported that quite recently two firms, one in London, had been approached with a view to supplying castings similar to those used in the bomb illustrated. It was alleged that they were required for some chemical process, but suspicion was aroused and the orders were rejected. The spirit of the times in France was further illustrated in the same issue by a short note on a strike among the ironfounders of Paris. The men had appealed to the "immortal principles" of 1789 in submitting their demands to the employers. The masters did likewise in furnishing reasons why the men's demands should not be granted. The men sought a minimum wage of sixpence an hour. The employers replied that the demand was unjust and inhuman, for it would lead to all young workmen with insufficiently developed ability and to all old workmen whose infirmities had rendered them incompetent being denied employment. The men sought the immediate and complete suppression of piecework and job work. The masters would not agree on the ground that piecework was the first step in the emancipation of the worker. The men sought the abolition of all overtime or alternatively double pay for such time, the day to be fixed at ten hours and Sunday work to be counted as overtime. The masters replied that foundry work, from its nature, rendered extra hours of work necessary, and for those hours extra wages could not be accorded. As regarded Sunday work, they argued that as it was voluntary it could not be counted as overtime. The men desired that foremen and heads of shops should be nominated by the masters, and that the suggested appointments should afterwards be discussed and voted upon by the men. The Gallic logic of the masters apparently became exhausted at this point. All that they would reply was that the claim was so contrary to the principle of liberty and to common sense that it could only be met by refusal.

Railway and Road Matters.

THE first of the G.W.R. schemes sanctioned by the Government for the relief of unemployment has just been completed. This is the doubling of the line between Scorrier and Redruth in Cornwall, a distance of just over 1½ miles. The company now has a double track throughout, from Paddington to Penzance, a distance of 305 miles, except for a short distance over the Saltash Viaduct.

WHEN the Great Western summer train service is brought into use on July 7th, the Torquay Pullman Limited from Paddington to Paignton and back will run daily instead of on Friday, Saturday and Monday only. A new Sunday morning express from Plymouth, Exeter, and Taunton to Paddington and a Sunday evening express from Bristol to Paddington, will be provided, whilst an express from Cardiff at 8 a.m., due at Paddington 10.45, will run daily, except on Saturdays and Sundays.

UNDER the Railways Act, 1921, Sec. 59, the Railway Rates Tribunal has to review each year the standard charges in operation. In reply to an inquiry from the Tribunal, the companies state that they do not desire to lay any proposals before the Tribunal for a general increase of charges. They emphasise, however, that this must not be taken to preclude them from bringing forward proposals for increasing charges, when, in their view, circumstances justify such a course. The decision of the companies, as stated in their letter to the Tribunal, is to afford every assistance in their power to the Tribunal. But after a full consideration of the position, and having regard to the industrial and economic conditions of the country, they are still doubtful whether a general increase of charges at the present time would result in any material improvement in their financial position.

AN interesting item in the new works programme of the London and North-Eastern Railway is that automatic signals of the colour light type are to be provided on the 26 miles between Skelton Bridge—4 miles north of York—and Northallerton. That length includes the 11 miles between Blue and Thirsk which were equipped with automatic signals in 1904. The remarkable feature about that stretch of line is that though there are four lines of way on the south and the north side of it, it not only, because of the automatic signals, remains a double line, but between 1904 and 1925 it carried an increase of 27 per cent. in the number of trains. Even now, although under the above-mentioned programme there is to be considerable quadrupling between York and Northallerton, 6 miles of the 11 are to continue as double line only, and the remaining 5 miles are to have one additional line.

THE Railways (Valuation for Rating) Bill, now before Parliament is a measure that, after a long period of discussions, has been agreed upon between the railway companies and the rating authorities. The rating of railways is a peculiar subject, as will be appreciated when we remark that should the direction of a railway pass through a parish to only a small degree, the area covered justifies, in law, that parish sharing in the profits of the whole railway system. When the Rating and Valuation Act of 1925 was before Parliament an effort was made to deal with the question, but it was found to be too involved, so the clauses thereon were withdrawn on the understanding that the subject should be dealt with later. As said above, the present Bill is an agreed measure. Mr. Greenwood, the Minister of Health, in introducing it, said that it was admitted that the present method was unsatisfactory, and that the only scientific way to deal with the difficulty was to rate railways as a whole, and not on a parochial basis.

ACCORDING to the Board of Trade export table, the value of the railway material sent overseas during the first three months of the present year was as follows; the corresponding figures for 1928 and 1929 are added in brackets:—Locomotives, £851,486 (£729,284, £700,187); rails, £729,964 (£779,151, £1,078,343); carriages, £438,155 (£492,643, £865,688); wagons, £760,885 (£708,151, £1,052,589); wheels and axles, £87,166 (£111,580, £259,551); tires and axles, £179,260 (£142,128, £170,218); chairs and metal sleepers, £200,462 (£131,649, £271,009); miscellaneous permanent way, £226,358 (£274,346, £335,267); total permanent way, £1,459,650 (£1,484,573, £2,149,817). The weight of the rails exported was 84,787 tons (93,545 tons, 125,293 tons), and of the chairs and metal sleepers, 20,508 tons (13,911 tons, 27,212 tons). The value of the locomotives shipped in the month of March last was £314,283, which included India, £280,583; the Argentine, £15,163; South America, other than the Argentine, £8558; Straits Settlements, £2004. The value of the rails exported during the same month was £265,333, which included the Argentine, £139,222; New Zealand, £25,522; British West Africa, £15,405; South Africa, £14,200; Straits Settlements, £9297; Portuguese East Africa, £2887; India, £2599.

THERE are at least two sides, if not more, to the question of the privately owned wagon. Each side advances strong arguments and confounds its opponents, only to be itself confounded by some fresh truth. It is therefore refreshing to have the opinion of one who, after years of long and intimate acquaintance with the subject, is no longer actively interested. We have in mind a letter which appeared in the *Manchester Guardian* from the pen of Major H. Angus Watson, for many years the general superintendent of the North-Eastern Railway, and, because that company was the only railway that compelled coalowners to use railway wagons, one who may be regarded as an authority. He observes that coal is a most exceptional commodity to handle; the peculiar feature about it is that large stocks have to be kept in readiness at the collieries for immediate railway conveyance. Railway companies profess only to provide wagons for conveyance, and have never laid themselves out to furnish wagons for warehousing. "This, surely, is not the time to force them to embark on it when money is so difficult to raise and they have so many more claims for real railway expenditure which they are unable to meet for want of funds." On the North-Eastern it was, and is, different. The geographical position of the counties of Northumberland and Durham is quite exceptional, owing to the proximity of the collieries to the factories and docks, and, consequently, there is no necessity for warehousing.

Notes and Memoranda.

A TUNNEL 6ft. in diameter by 600 yards long is being made under the river Hooghly to accommodate electric cables between Calcutta and Howrah. It is to be at a depth of 93ft. below the river bed.

MOST of Canada's platinum is recovered in the treatment of the nickel-copper ores of the Sudbury district, and the increased production of these ores indicates that Canada's output of platinum metals is likely to grow. The output in 1929 of platinum produced by Canadian, United States and British refineries from Canadian mattes and residues was 12,811 oz., and of palladium, rhodium, &c., 13,717 oz.

THE Home Secretary announces that he has made draft regulations for factories employing the processes of electrolytic chrome plating and anodic oxidation. The processes are now certified as dangerous, and the chief requirements of the new regulations are exhaust ventilation, provision of protective clothing, washing facilities, periodic inspections of the hands and forearms, and periodic medical examination by a doctor empowered to suspend workers from employment in processes involving contact with the liquids.

THE possibility of making illuminating gas more powerfully odorous with the object of preventing poisoning through leakage is attracting attention, and a pamphlet on the subject has been published as No. 6 of the *Abhandlungen aus dem Gesamtgebiete der Hygiene*, edited by Dr. R. Grassberger of the University of Vienna. A large number of experiments made with various substances of sufficient volatility and powerfully odorous showed that the liquid hydrocarbons separating from compressed oil gas and the light oil pre-distillates of gasworks were most suitable. So long as it is impossible to transform the carbon monoxide of the gas into methane, it is suggested that the gas should be impregnated with the vapours of these materials.

OUR contemporary *Vulcan* has recently published an analysis of breakdowns which occurred to dynamos and electric motors under the inspection and insurance of the Vulcan Boiler and General Insurance Company, Ltd., during the year 1929. The percentages in all cases, except those of the direct-current dynamos, bear a remarkable resemblance to the figures published last year. With direct-current dynamos the percentage of breakdowns to field coils has decreased, both as regards numbers and cost, but there has been an increase in the case of the commutators of these machines. When the number of direct-current motors and the number of alternating-current motors is taken into consideration the percentage cost of repairs is practically the same for each type of machine, and almost identical with those published last year.

CANADA possesses important resources in mica, a mineral which, on account of its superiority as an insulating material, has come to be indispensable to the electrical industry. Both of the commercial varieties of mica—termed, by the trade, amber mica and white mica—occur in Canada; the deposits of the former are the more important. The occurrences of amber mica are found chiefly in those parts of Ontario and Quebec contiguous to Ottawa, and within a radius of about a hundred miles. This district was formerly the seat of an important mica industry, and up to a few years ago it furnished the bulk of the world's supply of amber mica. Foreign competition in recent years has led to a rather serious falling off in production but the deposits are by no means exhausted and are still capable of supplying large quantities of mica should readjustment of the present economic situation warrant their being again actively worked.

AN interesting recent addition at the Home Office Industrial Museum in the Horseferry-road, Westminster, is a small building erected in the yard to demonstrate the effects of unfavourable atmospheric conditions in workrooms and methods by which the conditions can be remedied or their effects mitigated. Means are provided for ventilating the building by regulated air movements, heating by convection or radiation and humidifying the air to any required degree over a wide temperature range. Thus, widely differing conditions can be attained, such as those found in warm humid cotton weaving sheds, steamy laundries and dye houses, at hot furnaces, in insufficiently warmed workrooms, and so forth, and the effects of air movement, and different methods of heating, in improving the conditions practically demonstrated. It is hoped that the building will prove of interest and use, not only to those concerned with industrial conditions, but also to heating and ventilating engineers, architects, and others concerned with the ventilation and heating of buildings generally.

ONE of the most interesting plans at present being considered in the electrical industry is for the transmission of power from Norway to Germany. The idea is not new, but, judging by the attention now being paid to it in both Norway and Germany, it seems to be getting somewhat nearer realisation than it has ever been before. The present plan is for the transmission of 500,000 kW, to be increased later to a million. In order to transmit such a large amount of power several more waterfalls in Norway would have to be harnessed, some of which already belong to the Norwegian Government. It is no longer proposed to cross the Oere Sound and the Baltic Sea with submarine cables, but to cover the whole distance from Norway to Germany by overhead cables. As both the Oere Sound and the Baltic Sea between the islands of Laaland and Fehmarn are comparatively shallow, it would, it is anticipated, be possible to lay the foundations for the transmission masts in the sea. The masts would be in the form of towers, perhaps as much as 200 m. high. Eventually the transmission would be effected by six lines and at a tension of 380,000 volts. Admittedly, the technical difficulties would be considerable and the question of how much the power would cost by the time it reached Germany is also of the greatest importance. In America, it is said, a length of over a kilometre between two successive masts is being risked, but in Germany the longest free span so far is only 860 m. As the distance between the mainland and Fehmarn and Laaland is about 20 kiloms., from twenty to twenty-five masts at least would have to be built at great cost in the open sea.

Miscellanea.

IT is proposed by Imperial Chemical Industries, Ltd., to put up a synthetic nitrogen factory in South Africa.

A GRAIN elevator with a storage capacity of 2,500,000 bushels is to be put up at Fort Churchill, the terminus of the Hudson Bay Railway, in Canada.

IT is reported from Vancouver that the Harbour Commission will soon start work on a number of improvements to the port in the form of a new ocean pier, water front cold storage plant, fish storage and fish wharf, and additions to three terminal grain elevators which will add 5,500,000 bushels to the port's grain storage capacity.

ALTHOUGH the village of Aughnacloy, Tyrone, is far from the madding crowd, it is not far enough from the radio interference which is set up by the electric pump supplying water to the local reservoir. The twenty wireless licence holders of Aughnacloy have accordingly petitioned the authorities to stop the pump at 6 o'clock every evening, and the complaint is said to be receiving sympathetic consideration.

A NEW cotton picking machine, made by the International Harvester Company, is attracting considerable attention in the Southern States of America, where it was recently tested on a Texas cotton field. The machine, it is stated, picked cotton in competition with a trained group of negro cotton pickers and not only did it pick more cotton than the negroes, but the cotton gathered was of higher quality than the hand-picked. The machine is operated by compressed air.

A PRIVATE company has been formed in Paris to erect the special buildings which will house the International Wireless Exhibition in the autumn. This will probably be the largest show of the kind ever held in France, as it will unite the rival trade interests which have held separate exhibitions in past years. The site chosen for the "International Salon" is close to the Montparnasse railway station, in the Latin Quarter. The provisional dates for the Show are September 26th to October 9th.

A FACTORY and office buildings are to be put up by the Sperry Gyroscope Company, Ltd., on the Great West Road, near Brentford, where it crosses the Grand Junction Canal. It is noteworthy that this vicinity has lately become very popular as a manufacturing centre, as within the past two or three years six new works have been erected thereabouts, including a cement wharf, a tire factory, a fire extinguisher factory and two motor car works, besides several other minor industries.

THE Egyptian Public Works Department has received sixteen British and other European tenders for carrying out the North Delta electricity scheme. Callender's Cable Company submitted the lowest tender, namely, £E505,000, and the Entreprises Générales Electriques et Industrielles submitted the highest, £E1,196,000. The General Electric Company, with the Brown-Boveri Company, quoted £E511,000; Siemens Brothers, £E545,000; Savigliano, of Turin, £E556,000; Electro-Entreprises, of Paris, £E567,000; Allegemeine Electricitäts Gesellschaft, of Berlin, £E584,000; British Insulated Cables, £E602,000; Elin, of Vienna, £E619,000; Società Edison, of Milan, £E701,000; Mausermann, £E872,000.

THE electrification of the Singu Oil Field by the Burmah Oil Company has been completed and there has been a considerable addition to the load on the power-house at Yenangyaung. This station, which now serves the two main oilfields of Burma, is, says *Indian Engineering*, one of the best examples of modern power-house design in the East. A 4000 kW turbo-alternator has been added to the Burma Corporation's hydro-electric station at Namsan Falls, bringing the total capacity of the station up to 10,000 kW. This system is unusual in that a steam turbine station and a Diesel generating station are running in parallel with the hydro-electric station. A new boiler and a 2850 kVA steam turbo-alternator are being added to the Burmah Oil Company's power station at Syriam.

THE market for farm equipment in Poland during the past year was not favourable. Despite the fact that crop yields were better than the post-war average, 1929 was an unsatisfactory year for Polish agriculture. Extremely low grain and produce prices, particularly during the last six months of the year, severely curtailed the purchasing power of the peasants, with the result that the buying of implements fell off steadily as the year progressed and farm prices continued their decline. By the end of the year the Polish agricultural community was in a difficult condition and was buying only those things which were absolutely necessary. The decline in the implement imports during 1929 was occasioned wholly by the reduced purchasing power of the farmers, and not by any improvements in the output of the domestic implement factories. There was no improvement in the general agricultural situation during the first two months of 1930, and the consensus of opinion among authorities is that the complexity of the situation will continue at least until the next harvest. Implement dealers likewise take a pessimistic view of the market prospects for the first half of 1930.

AT the port and harbour of Cochin, which is situated on the West Coast of India in latitude 9° 58′ N., longitude 76° 14′ E. and is the only safe and sheltered harbour in British territory between Bombay and Cape Comorin, developments are taking place with the object of making the port into a first-class harbour. A dredged channel leads into the harbour and is practicable at all seasons of the year for vessels drawing 28ft. Inside the harbour vessels lie at swinging buoys. Vessels up to 475ft. in length can at present be accommodated at three of the buoys and a vessel of 400ft. of a maximum draught of 20ft. can also be accommodated at a buoy. It is expected that five berths for large steamers and two berths for steamers up to 400ft. in length will be available shortly. The port is connected with the hinterland by rail and water transport. The railway facilities are to be greatly increased in the near future, which circumstance will further enhance the importance of the port to the planting and producing districts of South India. There is an engineering firm which can undertake repairs. The total number of vessels which called at the port during 1927–28 was 1174, of 1,005,354 registered tons.

THE LOCHABER HYDRO-ELECTRIC POWER UNDERTAKING

MESSRS. C. S. MEIK AND HALCROW, MM. INST. C.E., WESTMINSTER, ENGINEERS

(*For description see page 508.*)

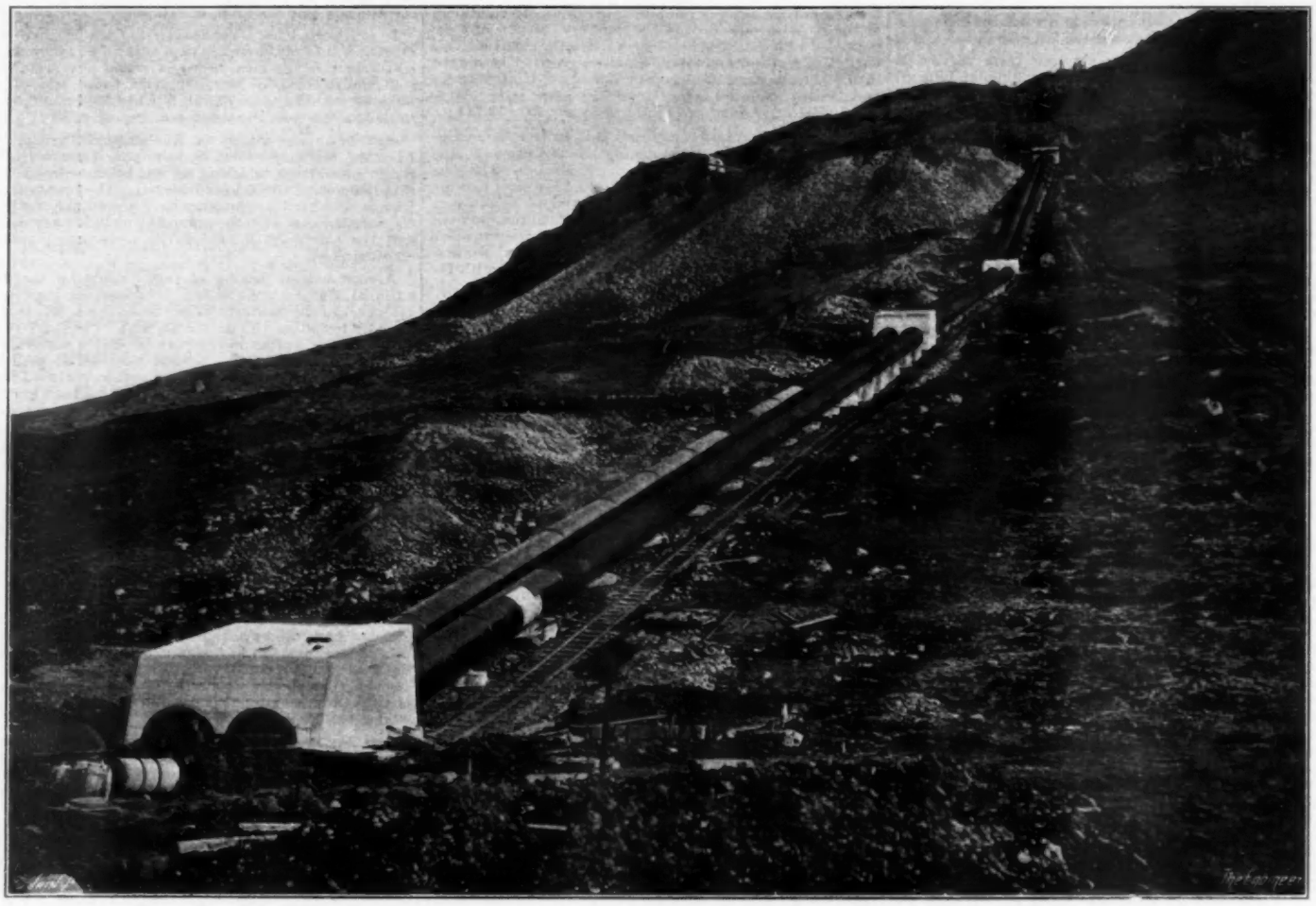

FIG. 26—LOOKING UP THE PIPE LINE FROM ANCHOR BLOCK NO. 4

FIG. 27—VIEW OF PIPE LINES, SHOWING POWER-HOUSE AND ALUMINIUM FACTORY

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THE ENGINEER.

VOL. CXLIX No. 3878

MAY 9, 1930.

Inspiration and Progress.

To the non-aeronautical section of his audience the most interesting revelation made by Professor R. V. Southwell in the course of his James Forrest lecture on Wednesday was probably the fact that scientists have as yet not definitely discovered why an aeroplane flies. For many years it used to be supposed that the lifting force developed by an aerofoil advancing through the air was produced by the air pressure on the underside. That view, directly traceable to Sir Isaac Newton, persisted throughout the early experimental days of aeronautics and survived for several years after mechanical flight had been achieved. Not until 1910 or 1911 did it suffer eclipse. Round about that time the National Physical Laboratory proved by measurements of the air pressure on both surfaces of an aeroplane wing that over half, and in some cases as much as two-thirds, of the lift was produced, not by the pressure on the underside, but by the vacuum or reduction of pressure on the top side. This discovery led almost immediately to an improvement in the efficiency of aeroplanes. The form of the top surface, previously regarded as more or less unimportant, received close attention. New curves for it were established and precautions were taken to ensure that these prescribed curves were reproduced with close accuracy in the manufacture of full-sized wings. It would be wrong to attribute the amazing developments made in the performance of aeroplanes during the war wholly to improvements in the sectional forms of the wings. It is, however, true that the great progress registered between 1914 and 1918 was effected on the general supposition that an aeroplane flew because, primarily, of the reduction of pressure on the top of its wings and secondarily because of the increase of pressure on the underside. There were, however, even in those days some who sought a deeper explanation, notably Lanchester in this country and Prandtl in Germany. Their views have now become widely accepted; but, as Professor Southwell very clearly and ably demonstrated, the modern theory, based on a circulation of the air round the wing, is characterised by its complexity and increases rather than diminishes the difficulty of understanding why an aeroplane flies.

The general reader is probably not particularly interested in the refinements of modern aeronautical science. He cannot, however, fail to have his philosophical attention aroused by the fact that the development of the aeroplane and all that has been achieved with it in war and in peace has so far been accomplished without a complete knowledge of the primitive causes which make flight possible, largely, in fact, with an erroneous impression as to the nature of these causes. The vast amount of highly skilled research and investigation which has been and is being spent all over the world on the development of aeronautics and the rapid progress of performance which has resulted therefrom undoubtedly encourage in the public mind the belief that aeronautics is now an exact science, that there is little or nothing associated with artificial flight which cannot be brought within the field of fundamental analysis. That belief is not justified. Experience and precedent—or, if the reader likes, rule of thumb—rather than mathematics still guide the aeroplane designer to an extent which few but the initiated can guess. How far aeronautical theory still lags behind aeronautical practice is strikingly revealed by a simple statement of the present position achieved by the mathematicians in their endeavours to formulate a rational explanation of the flight of an aeroplane. The circulation hypothesis, if the fluid in which the aerofoil is immersed be assumed inviscid, can be brought within the region of mathematical analysis. When it is so analysed it is found to yield very good agreement with the facts of observation so far as the lift developed is concerned. It is, however, completely silent as regards the drag or resistance of the wing. The resistance is not and cannot be recognised by the theory. In other words, according to the mathematicians a wing once started in forward motion should continue indefinitely to develop lift without power being expended on it. How far theory fails to agree in this respect with practice may be judged by the fact that something like 1200 horse-power is required to overcome the drag of the Supermarine Rolls-Royce machine flying horizontally at a speed of 357 miles an hour. Mathematical theory has reached the stage of explaining why an aeroplane sustains itself in the air, but not why it should require an engine in order that it may do so. We do not intend our remarks to be in any way a criticism of the futility of mathematics. Mathematicians are quite keenly alive to the shortcomings of their investigations. Indeed, no one has taken a more prominent part than Prandtl himself in demonstrating by practical experiment the disagreement between the classical mathematical theory and the actual behaviour of air as it passes over and under an aerofoil. He has shown that turbulence, vortex motion and the establishment of dead air areas profoundly modify the *régime* assumed to hold good in the mathematical analysis of the problem. It is scarcely reasonable to hope that analysis will be able to follow the demonstration. Yet the performance of aeroplanes will, it is certain, continue to undergo improvement as a result of the combination of imperfect theory with experience, model research, and full-sized trial.

The situation, as we have suggested, is, philosophically, one of very great interest. It emphasises, in a forcible manner, a fact insufficiently realised by the public, the fact that many, if not all, of man's most important or most striking achievements have been effected in spite of his deep ignorance as to why it should be within his power to accomplish them. Is it not strange that we should be permitted to do so much with our eyes but half open to the nature of the forces which we employ, that we should so often and so successfully, while yet blindfolded, strike the right path? Has man's advance in the mechanical arts been inspired or has it been wholly a matter of a blind pertinacity which has led him to explore every possible turning until he has struck that one which would lead him to his goal? It seems safe to say that both factors have played their part and that they will continue to do so in the future. It is not alone in mechanical flight that the limits within which success is realisable are drawn very narrowly. Nor is it in flight alone that we have struck those limits quickly—when the time was ripe—with relatively little difficulty or exertion. Time and again we have passed first to success and then afterwards to a realisation of the narrowness of the margin within which success was possible. Not once, but often, has some feeble theory led to brilliant results, to results which, without the

precedent theory, we should probably not have reached by haphazard discovery for many years. Therein lies, not a condemnation, but a convincing justification of scientific research and mathematical theory with all their shortcomings and lack of reality.

Our Universities.

THE period for which the Treasury grant for universities and colleges was fixed at its present figure will come to an end in a few weeks, and—we may trust with an eye to the future—the University Grants Committee has been engaged during the past year in domiciliary visits to all such institutions which enjoy the benevolence of the Exchequer. Within the past few days it has rendered an account of its work. It is a long report and only those who are directly interested in teaching are likely to pay much attention to it. But it contains some data which are of fairly general interest, and many observations upon the management and organisation of teaching institutions which it ought to be everybody's business to know something about, for, after all, a great deal of the taxpayers' money is expended annually upon universities, the grant made by the Treasury in 1925 for a quinquennium amounting to over one million and a half pounds sterling. It is, we surmise, not generally known that little short of fifty per cent. of university students in England, Scotland, and Wales are in receipt of "financial help from other than private sources to attend University Institutions." We do not propose, however, to summarise the statistics given in the report, but to discuss one or two of the educational problems which are raised by the Committee.

If the man in the street were asked what was the prime function of a university, he would certainly say the education of youth. If, however, he happened to be a "don" and not just an ordinary man, the reply would be "the advancement of knowledge." These are two very different things. The former represents the modern view; the view of the man who desires to put his learning to a specific money-making purpose. The latter is the ancient view, that of the true scholar who rejoices in scholarship and does not care a brass tack whether it is of any use or not. It was the prevalence of that opinion which kept engineering outside the pale of the older universities for so many years; cultivation rather than education was the aim of those universities. Now it is improbable that any more than a very small proportion of engineering students are particularly devoted to the advancement of knowledge as an end in itself. They enter the universities to be taught and to secure degrees which will help them in the pursuit of lucrative occupations. What qualities, then, should be required in the teaching staff? Our man in the street would instantly reply that it should be able to teach; but the faculty would be by no means so positive. It might even go so far as to assert that the prestige which an international reputation for research would bring to the university should outweigh the ability of its professors to impart knowledge to second-rate, utilitarian intellects. That is not an imaginary picture of the academic mind; it is drawn from life, and is reflected in the report before us. "It was suggested to us on one of our visits," says the Committee, "that in the homage now paid to 'research' there lay some danger to the university's function of teaching, if research were too exclusively measured by the output of books and articles in learned periodicals; and we are inclined to agree that in the long run the teaching of a university is likely to suffer, if its junior staff are led to think that in the matter of advances of salary or promotion to higher posts, a record of stimulating and successful teaching will count for less than an impressive list of published research work." The implication here would seem to be that whilst the "junior" staff should be promoted for ability to teach, such a qualification need not be looked for amongst the professors. We venture to suggest to the Committee that the word "junior" should be struck out, and that ability to teach should be regarded as the prime qualification of every member of the educational staff. This does not mean that we have any desire to cut staff research work out of universities. Far from it; we agree with the Committee that "it is by no means necessary for a university teacher's original work to be restricted to the production of highly elaborate treatises and papers; . . . part should be directly designed to fertilise his teaching of students." But we do say that since students pay their fees to be taught and not only to increase the prestige of their universities by the encouragement of research, teaching should not be regarded as of equal importance with research, but definitely as of greater importance. It is, indeed, difficult to see why superiority in the great art of teaching should not bring more prestige and honour to a university than research, which is not essentially and of necessity a university subject, and in many cases may be better pursued in the tranquillity of a private laboratory. If it is held to be desirable that original investigations should be pursued in all universities, both for the increase of knowledge and the credit of the school, then it would seem that the wisest course is to relieve the research workers, not only of all responsibility for teaching, other than the delivery of occasional lectures, but particularly of the burdensome routine of administration. It is manifestly absurd to appoint a great thinker and worker, and possibly, too, a great teacher, to the highest position in a faculty, and then oblige him to devote many weary hours each week to committees and councils and to affairs generally which could be as well, if not better, performed by a different class of mind. Yet in many, if not all, our universities it is the practice for the heads of the teaching staff to attend to administration and thereby sacrifice valuable time, which, if it were not given to teaching, might be spent on private study and research.

There is, we suggest, a real necessity to distinguish between universities of the old order and those of the new. In an attempt to bring themselves into line with modernity, Oxford and Cambridge established Chairs of Engineering. Now, engineering is on a different plane from any other subjects taught before that time in those seats of learning. It is an industrial subject. Those who take it up, with relatively few exceptions, want to make a living by the control of factories, by the design of machines, or by the execution of civil engineering works. Science with them is not the end itself; it is merely a step towards an object in which science *per se* enters but little. It is not impossible that in the course of time we may see differentiation in the universities; we may, for example, see Cambridge devote itself more and more to the science of engineering and become a centre of learning in that profession rather than a place of preparation for an industrial career. But that time is not yet; not even at Oxford and Cambridge, and still less in the technical colleges attached to universities of more recent foundation. In all these colleges the students are there to acquire fundamental knowledge which will be of direct value to them in their vocations, and they are justified therefore in asking that teaching should be the first consideration of the educational staff. They are far less concerned about the prestige of the professors, acquired by research and the writing of learned theses, than about the thoroughness with which they have been taught. Those with whom they seek employment are of the same way of thinking. It is nothing to them that a student may claim that he sat at the feet of a professor with an international reputation for learning, and that he has secured a degree at a university which basks in the radiance of that professor. Employers ask for men who have been thoroughly taught and who possess sound useful knowledge which can be applied to the material engineering problems of the day. To produce such men it is necessary that the art of teaching should be regarded as the first function of engineering schools, and that "the advancement of knowledge," great as its importance is, should not be allowed to stand in its way. By all means let us see our universities devoting attention to research; let them, if they can, support great scientists, great intellects devoted solely to the advancement of knowledge; but let not such eminent men be on the teaching staff unless they are also possessed of the qualities which make great instructors. Above all, let not the universities—as they now do—refuse promotion to men of recognised teaching ability because they have not won international reputations by "books and articles in learned periodicals." Teaching, properly considered, is amongst the greatest vocations in the world.

Obituary.

SIR BENJAMIN LONGBOTTOM.

IT is with sincere regret that we have to report the death from pneumonia of Sir Benjamin Longbottom in his 54th year at his home at Totteridge-lane, Herts. Although he was a Yorkshireman by birth, being the son of Mr. John Singleton Longbottom, of Gomersal, near Leeds, and though he served his apprenticeship with the Phœnix Dynamo Company, of Bradford, Sir Benjamin's business life was chiefly connected with Manchester and the firm of Electromotors, Ltd.—now associated with Laurence, Scott and Co., Ltd., Norwich, under the title of Laurence, Scott and Electromotors, Ltd.

After leaving Bradford, he was for some time in the employment of the General Electric Company, Ltd., before taking up the management of Electromotors, Ltd., in 1900. Under his energetic direction the latter company made rapid strides in the manufacture of electric motors, formerly of the direct current type, but latterly for both direct and alternating currents, and upon the amalgamation with Laurence, Scott and Co., Ltd., Sir Benjamin became one of the joint managing directors.

He was a very keen business man, whose integrity and charm of manner endeared him to all with whom he came into contact. He was one of the founders of the British Electrical and Allied Manufacturers Association, familiarly known as the B.E.A.M.A., and acted as chairman of that organisation from 1922 to 1925. He was also the chairman of the British National Committee of the First World Power Conference in 1924 and received a knighthood in 1925.

By his death the Manchester Chamber of Commerce has lost an extremely valuable member. Sir Benjamin took a very prominent part in the work of that Chamber, particularly in connection with the engineering and metal section, of which he accepted the chairmanship in 1920 upon the death of Mr. F. G. Goodbehere. By virtue of that election Sir Benjamin secured a seat on the board of directors, which he occupied until the end of last year. He was also honorary treasurer of the Chamber for some time, and was a member of the Institutions of Mechanical and Electrical Engineers and was on the Council of the latter. There was scarcely any engineering activity in Manchester with which he was not intimately associated. He was President of the Manchester Association of Engineers in 1926–27, President of the Engineers' Club at the time of his death, and was an active member of the Manchester Engineering Council—an institution which has played no small part in maintaining a friendly spirit amongst both employers and workers in the local engineering industry, of which little is known outside Manchester. His death will be acutely felt by a very wide circle of friends connected with the electrical engineering industry.

The Lille Fair.

(By our French Correspondent.)

As the character of a Fair is reflected by local industries, there was reason for believing that the recent Fair at Lille would be particularly representative of general engineering, textile manufacture and mining. It is true that the machinery hall was well filled, and what was shown was interesting, but the drawback of some of the Fairs on the Continent is the small area available for engineering exhibits. If more space were provided for the engineering section, and it was suitably supported, the Lille Fair would gain considerably in industrial as well as commercial interest, and its growing popularity, as evidenced by the increasing number of exhibitors, would be of benefit to the manufacturing industries in the North of France. In the engineering hall there were several German and Belgian stands. Specialisation in heavy oil engines is carried out by a number of firms in Belgium which do a large foreign trade in them, and the Société Moteurs "Moës" of Waremme (Belgium), showed a marine set for barges and fishing boats, which are now being, almost generally, equipped with this type of prime mover. In this design a single-cylinder hot-bulb engine of 25 horse-power is mounted on a ribbed cast iron bed carrying the differential reversing gear and steering post, the last-named component being cast with a gear case, to which is bolted a propeller shaft tube. This tube gives to the propeller shaft vertical and horizontal movements by means of pinions. The steering is therefore done by the propeller itself, and for canal barges the propeller can be lowered when the boat is travelling light, and can be turned at right angles to the boat to save room in the locks. In some other systems the same result is obtained by the use of spherical joints.

Only two French firms exhibited heavy oil engines, both of them being of the single-cylinder horizontal type—the Etablissements Duvant of Valenciennes, which is one of the oldest gas engine firms in France and is particularly successful with solid injection engines, and the Moteurs Pruvost of Lille. In metal-sawing machines there is a tendency to use vertical saws mounted in slides on vertical columns. The feed is effected by ratchet and pinion gear, while the release on the upward stroke is obtained by helical springs acting against a cam arrangement. A machine taking 1 horse-power, which was shown, will cut a 4in. steel bar in 12 minutes. Of machine tools there were none, except a number of Ernault lathes, and some punching and shearing machines. Obviously, machine tool firms do not regard the Fair as offering a suitable means of reaching customers, but as practically everyone in the northern industrial region visits the Show, the opportunity for doing business certainly exists, as was proved by the number of machines of different kinds ticketed as being sold by those who did exhibit. There is plenty of evidence that foreign makers who have something new to introduce will find the Fair a convenient means of bringing it to the notice of buyers. With Roubaix as a weaving centre, it might have been expected that more prominence would be given to textile machinery, but German makers had this section practically to themselves, so far

as weaving machinery was concerned. There was a "pick up" loom with automatic change of shuttles by the Saechsische Webstuhlfabrik of Chemnitz, and another automatic loom by the Vogtl Maschinenfabrik of Plauen. Weavers are keenly interested in automatic looms, and until a few years ago, at least, their experience of them was not encouraging, chiefly through the time lost in broken threads, but the Germans hoped to demonstrate at the Fair that their looms are reliable.

Winding gears and rail tractors were shown by the Compagnie de Fives-Lille, the tractor having a "Junker's" engine with opposed pistons running on crude oil, and the general lay-out and the construction appeared to make it one of the most practical types of such vehicles yet introduced. Built for normal gauge, its weight is 7 tons, and it is said to be capable of hauling 50 tons. The use of these motor vehicles on railways is extending considerably, and while employed largely for shunting purposes, some hundreds of light machines, known as *draisines*, with petrol engines of 25 horse-power, are used for track inspection and for repair work. The Anciens Etablissements Cail of Denain made a special exhibit of the Steinmüller high-pressure steam generator, a feature of which is the capacity and arrangement of the tubes for ensuring a rapid circulation of a large volume of water. The tube ends are expanded in an annular or torus form inside the drums and end chambers. The mechanical grate is built up of plates in such a way that as they rotate on the end shaft, each plate drops down on the other with a shock sufficient to dislodge clinkers. The shaking is confined to the two plates that come in contact, and it is sufficient, it is claimed, to keep the grate quite clean. The generator is fitted with an economiser consisting of cast iron ribbed tubes, and is provided with steam jets for keeping the outside of the tubes clean. Longitudinal and rotary motions are given to the steam jets by a worm on the tube in conjunction with spur wheels and chains. There was a meagre display of electrical machinery, the chief exhibitors being Jeumont and the Electricité and Electromécanique S.A. of Brussels, the former making a feature of small totally enclosed motors suitable for running in a dusty or damp atmosphere, while the Belgian firm showed protected switches for high pressures as well as electrical welding machinery. There were several other welding machines in the hall, for electrical welding is extending rapidly in this country, as it is elsewhere.

The Chambre des Houillères du Nord et du Pas de Calais had arranged a particularly attractive stand, showing samples of coal and coal products, benzol and other oils, together with micro-photographs of coal structures, but what it intended to impress strongly upon the public with a series of diagrams was the change that has taken place in the conditions of the colliery industry during the past ten years. In 1913 the industry had to bear practically no social charges and taxes; in 1928 those charges had risen to more than 400 million francs. The coalowners in the Nord and the Pas de Calais paid in wages, dividends and taxes in that year more than 2000 million francs. The colliery industry started upon a new period of prosperity when it centralised the commercial services and improved the colliery equipment with a view to a reduction of costs, but the companies feel that having now done all that is possible to realise economies the industry is unable to support additional charges, which will inevitably be placed upon it when the proposed new social insurance scheme is put into operation. The Chamber of Commerce of Dunkirk had a pavilion in which documentary evidence was provided of the extraordinary development of that port, and a model of the 15,000-ton grain elevator which has been constructed there was shown. The equipment of the port consists at present of 151 hydraulic and electric cranes, four bridge elevators, two floating cranes, 44 steam cranes and 36 hydraulic and electric capstans. This complement is to be increased shortly by 34 electric cranes and two floating cranes, including one of 120 tons. Dunkirk has four dry docks, and new basins are to be constructed before long to enable vessels drawing 42ft. of water to enter the port and draw up alongside the quays in all weathers. Since 1913 the tonnage of ships entering and leaving the port has about doubled. The aim of the Chamber of Commerce is to make Dunkirk a port of transit not only for the north and east of France, but also for Central Europe.

Progress in Coke Research.

A RECENT report issued by the Northern Coke Research Committee outlines some of the more important results which were obtained in the Coke Research Laboratory at Armstrong College, Newcastle-on-Tyne, and at various works during the year ending December 31st, 1929. The report states that cokes obtained from "box tests" agree well with those made in full-scale oven charges, but "bag tests," while giving good results on the whole, are less reliable. Coke from "box tests" tends to be larger in size than the corresponding full-scale oven cokes. Uncompressed cokes have been shown to be more porous, larger and of higher shatter index than compressed cokes. Examination of gas cokes made from the same coal, in vertical and horizontal retorts, have indicated that "horizontal" cokes are larger, denser and of higher shatter index than "vertical" cokes. Examination of the influence of the size of coal on the resulting coke has shown that up to a certain degree of fineness the shatter index of a coke increases, with decreasing size of coal particle, and it is concluded that to obtain a strong coke the proportion of coal above ¼in. in size should be a minimum, whilst the influence of the coal below $^1/_{32}$in. is to some extent adversely affected by its liability to oxidise.

Cokes produced from the same good Durham coking coal in "patent" ovens in compressed and uncompressed charges and in beehive ovens were submitted to full-scale cupola tests, and it was shown that the uncompressed "patent" coke had the lowest melting efficiency, whilst the beehive coke was but slightly superior to the compressed "patent" coke.

A large number of cokes have been examined by the special combustibility test developed in the Northern Committee's Laboratory. Cumberland cokes have been shown to give lower maximum temperatures and greater carbon consumptions than Durham cokes. An examination of the influence of catalysts on combustibility has indicated that impregnation of a coke with ferric oxide causes a marked lowering of the maximum temperature and an increase in carbon consumption; conversely, with a coke containing a ferruginous ash, extraction of iron with hydrochloric acid diminishes the carbon consumption. It was not possible, however, to correlate the behaviour of cokes on combustion with their ash analyses.

A number of cokes have been prepared in an experimental oven which takes a charge of 3 cwt. of coal. Except in porosity, cokes made in this way are closely similar to the corresponding full-scale cokes, and it is concluded that this method has substantial advantages over "box tests." Utilising the experimental oven, blending experiments have been carried out with Northumberland high-volatile "non-coking" and typical Durham coking coals. Chemical examination has shown that the Northumberland coals, compared with Durham coking coals, are characterised by high moisture and volatile contents, by low caking indices and by low carbon and high oxygen and sulphur figures; laboratory tests at 600 deg. Cent., by the Gray-King assay, indicate that Northumberland coals produce smaller quantities of coke and gas, but greater quantities of tar and liquor than Durham coals. It has been found that, on carbonisation, Northumberland coals gave cokes of lower shatter index than Durham coals; blending experiments show that the mechanical strength of Durham cokes is considerably diminished by additions of 10–20 per cent. of Northumberland coals, but that greater proportions of the latter does not give a proportionate lowering of the mechanical strength. Caking indices determined by the Gray-Campredon method are found to give but little indication of the shatter index to be anticipated in a coke.

The Northern Coke Research Committee has collaborated with the Midland and Scottish Committees in preparing a standard specification for the shatter test—see below—and valuable results will undoubtedly be obtained as a result. The Committee is also represented on the British Engineering Standards Association panel for the standardisation of an agglutinating test for coal, and, at the request of that panel, is carrying out a certain amount of work on this test.

The report concludes by stating that, although since its formation the Committee has given much information as to variations in the quality of coke which may result from variations in carbonising conditions, the general trend of the research is to show that a knowledge of the intrinsic carbonising properties of the coal is of primary importance. The blending experiments have shown that the addition of quite small quantities of inferior coking coal produce a more than proportionate lowering in the quality of the coke, and as the majority of coke ovens and gasworks are carbonising coals which are in themselves almost invariably blends, and as coals are blended for export purposes, a knowledge of the fundamental principles involved in the practice of blending is of the utmost importance to the whole industry. For these reasons the blending programme is being actively pursued.

STANDARD SHATTER TEST FOR COKE.

The standard method for conducting the shatter test referred to above is as follows:—

(1) *Apparatus.*—The shatter test apparatus* shall consist of a box 18in. in width, 28in. in length, and approximately 15in. in depth, supported above a rigidly mounted cast iron or steel plate, not less than ½in. in thickness and not less than 38in. in width and 48in. in length. The inside of the bottom of the box when in its highest position shall be 6ft. above the plate. The bottom of the box shall consist of two doors hinged lengthwise and latched so that they will swing open freely and not impede the fall of the coke. Boards about 8in. in height shall be placed around the plate so that no coke is lost. To minimise the breakage of coke, which might otherwise occur while placing the sample in the box, the box shall be so suspended that it can be lowered to a convenient level for filling. Convenient forms of shatter test apparatus are shown in Figs. 1 and 2.

FIG. 1—COKE SHATTER TEST APPARATUS

(2) *Screens.*—For determining the breakage of the coke sample square-mesh screens with the following openings shall be used:—2in., 1½in., 1in., and ½in. These screens should be machine stamped from mild steel plates† with a limit of error of $^1/_{32}$in.

(3) *Procedure.*—Fifty pounds of coke, all over 2in., shall be placed in the box of the shatter test apparatus, the coke be levelled, the box raised and the coke dropped on to the plate. The box shall then be lowered and all the coke be shovelled into it indiscriminately, but taking care to avoid breakage. The box shall then be raised and the coke again dropped. When the coke has thus been dropped four times in all it shall be screened by hand in such a way that any piece which can pass through the screen in any position shall be counted as undersize, and the weights of coke of each grade shall be determined to the nearest ounce. If for any reason the shatter test cannot be made with a true average sample of the original coke over 2in., the grading of the coke taken for shatter test should preferably be such that the weight-ratio of the 4in., 3in., and 2in. grades is that found in a preliminary size analysis of the original coke.

(4) *Statement of Results.*—At least three tests shall be made and the results shall be stated as percentages—given to one decimal place—remaining on 2in., 1½in., 1in., and ½in. screens. The shatter indices reported shall be the average values of the percentages retained on the 2in. and 1½in. screens and shall be given to the nearest whole number only.

A single figure shall be understood to be the 2in. index unless otherwise stated. In future the 1½in. figure shall invariably be given in addition to the 2in. figure by stating the shatter indices in the form 74/86, where the figures are the 2in. and 1½in. indices respectively.

Where possible, the statement of the shatter indices shall be accompanied by a brief description of the coke; for example, as "blocky coke," "prismatic coke," "narrow oven coke," "compressed-charge coke," "beehive coke."

(5) *Tolerated Deviation.*—If the average deviation of the individual results from their average exceeds 3·0 and 2·0 at the 2in. and 1½in. screens respectively, the corresponding shatter indices shall be marked with an asterisk, and if it is desired to base any conclusion or to take any action upon the result, a further series of at least two tests shall, if possible, be made and the results thereof averaged with those of the original series.

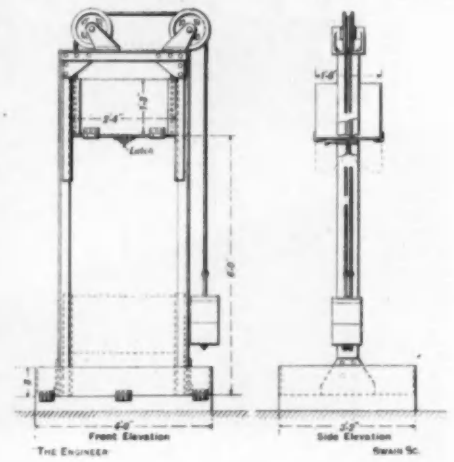


FIG. 2—COKE SHATTER TEST APPARATUS

* The essential dimensions of the shatter test apparatus are those given by the American Society for Testing Materials in "Standard Method of Shatter Test for Coke," Serial Designation: D141–23 (A.S.T.M. Standards, 1927, Part II., Non-metallic Materials, p. 571).

† Obtainable from G. A. Harvey and Co. (London), Ltd., Woolwich-road, London, S.E. 7.

ROLLING ALUMINIUM JOISTS.

A NEW development in structural material is the production of rolled aluminium joists, channels, and angles. At the works of the United States Aluminium Company the metal is melted in open-hearth furnaces of 20,000 lb. capacity, copper and other alloys being added, and the molten motal being cast into ingots 6ft. long and 12in. by 12in. or 15in. by 28in. in section, weighing 1000 lb. and 3000 lb. respectively. From preheating pits having automatic temperature regulation, the ingots, at about 900 deg. Fah., are taken to an electrically-operated blooming mill with 38in. rolls 7ft. long. All movements of the screw-down mechanism, mill tables and guides are effected by motors under the control of two men. The rolls are driven by a direct-current variable-speed reversing motor of 5000 H.P., having a 16ft., 35-ton fly-wheel mounted on the shaft. An electrically-operated shear, with tables, cuts the billets into the desired lengths, and they go then to an oil-fired heating pit, through which they travel on a chain conveyor. At the discharge end, an automatic loader transfers the billets to a roller table, which, in turn, serves the travelling tilting table of the rolling mill. This is a three-high mill, with rolls 27in. diameter and 5ft. long, except that in the last stand they are 28in. in diameter and 4ft. long. The rolled shapes then go to an electric heat-treating furnace, 100ft. long. As they leave the furnace they pass through water sprays, and then go to the straightening rolls and cut-off saws. The mill equipment includes a 10-ton overhead travelling crane built of high-strength aluminium alloys, and said to weigh some 10 tons less than a similar crane built of steel. Numerous shapes are rolled, up to 10in. joists and channels, but larger sizes will be produced later.

THE Roads Department of the Ministry of Transport has issued a memorandum containing recommendations for the standardisation of road direction posts, warning signs and traffic notices. The types of signs and traffic notices covered by the memorandum are grouped under fifteen heads, each of which is dealt with in detail. Twenty-one illustrative diagrams are attached to the memorandum. Signs at important road junctions and those erected to indicate specially dangerous features should be illuminated at night. Except where otherwise specified, the posts carrying all traffic signs should be distinctly marked black and white.

TURBO-GENERATOR AT THE PORTOBELLO POWER STATION, EDINBURGH

BRITISH BROWN-BOVERI, LTD., LONDON, ENGINEERS

(*For description see opposite page.*)

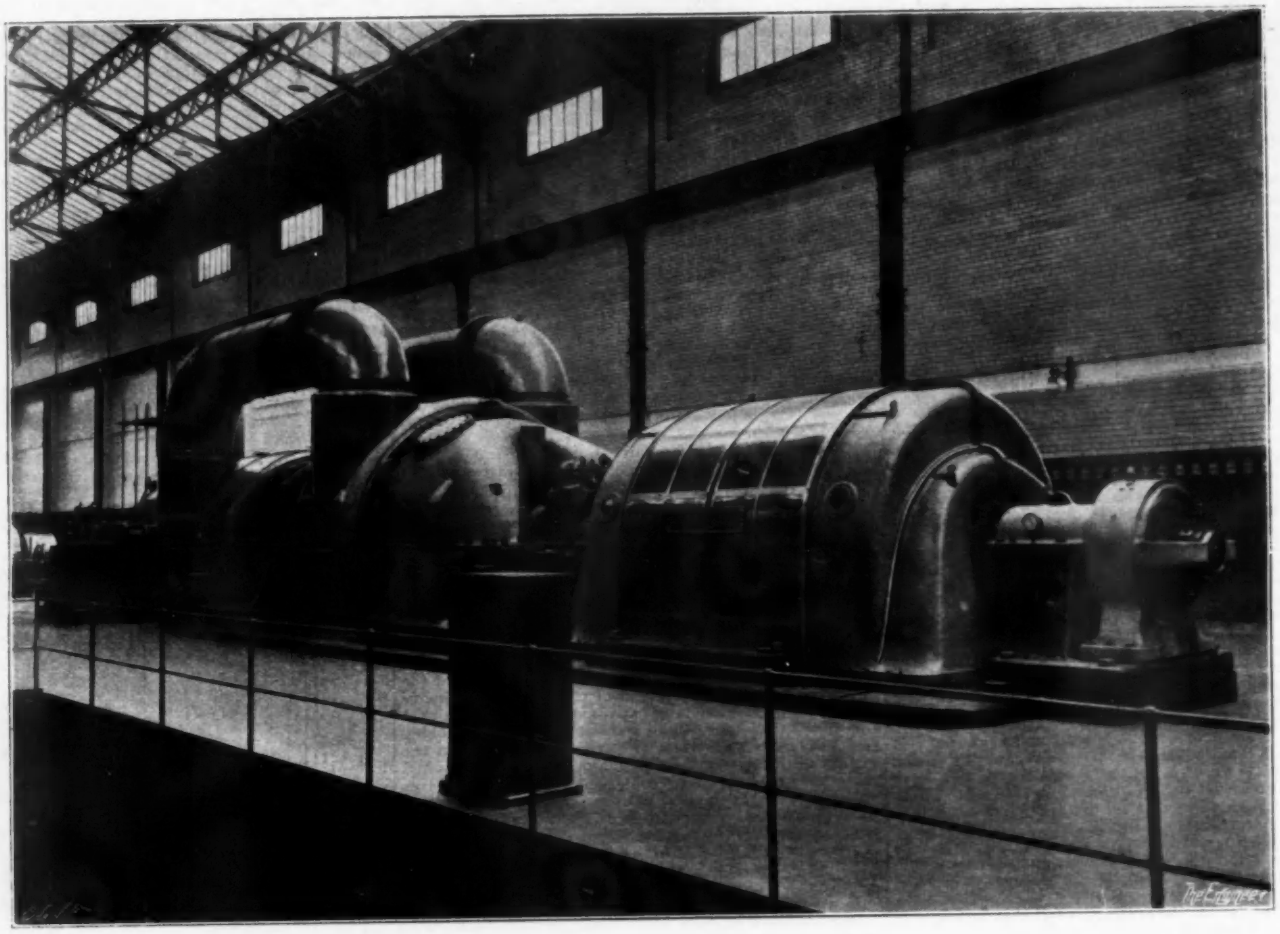


FIG. 1—31,250-KILOWATT TURBO-GENERATOR—ALTERNATOR END

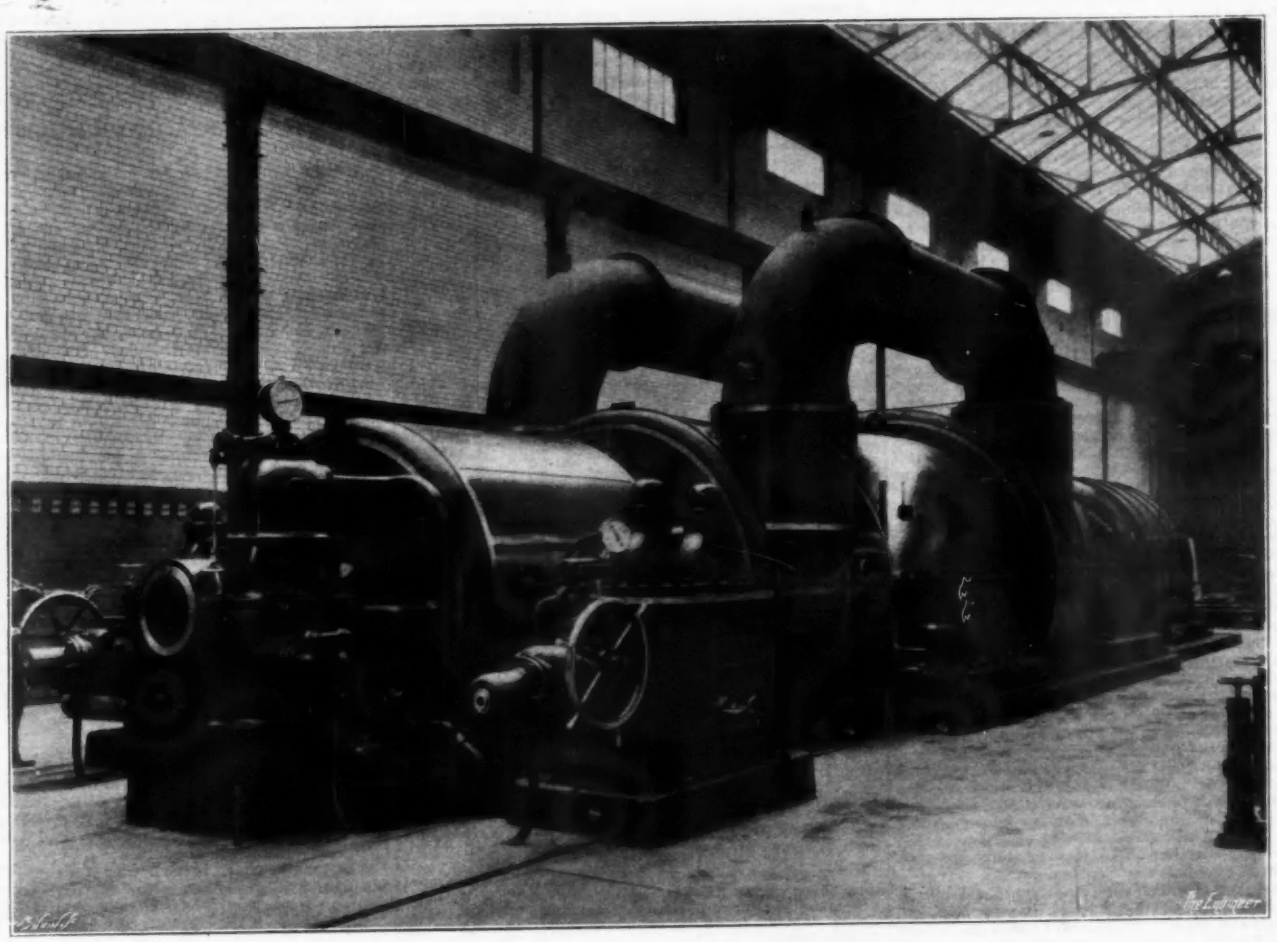


FIG. 2—31,250-KILOWATT TURBO-GENERATOR—STEAM END

Extensions at the Portobello Power Station.

ON Wednesday, April 30th, the day on which Mr. Herbert Morrison, the Minister of Transport, officially started up the Central Scotland electricity scheme, the ex-Minister of Transport, Lieut.-Col. The Right Hon. Wilfrid Wm. Ashley, officially opened extensions to the Portobello power station of the Edinburgh Corporation, the first section of which was opened by H.M. the King on July 11th, 1923. At that time the turbine room contained three 12,500-kilowatt setts running at 1500 revolutions per minute, and designed to operate with steam at a pressure of 290 lb. per square inch and a total temperature of 700 deg. Fah. There were six tri-drum water-tube boilers with integral superheaters and superposed economisers, each designed for a maximum continuous capacity of 80,000 lb. of steam per hour at a gauge pressure of 300 lb. per square inch. Some of these boilers are fitted with chain grate stokers, others with retort stokers.

Coal is received at the Baileyfield-road sidings, some 230 yards from the station. After each wagon has been weighed, it is discharged into an underground hopper by means of a rotary tipper, and the empty wagon is again weighed. Within the sidings, haulage is done by means of electric capstans. The underground hopper discharges the coal on to a belt conveyor, which passes through a tunnel under two roads, and a railway line conveys the fuel to the north-west corner of the boiler-house. From that point a short cross conveyor and two gravity bucket elevators convey it to the boiler-house bunkers. Besides feeding the short cross conveyor, the main belt conveyor may discharge coal into the station yard for storage purposes, within the range of an electric locomotive grab crane. The main storage bin is alongside the coal sidings at Baileyfield-road, where up to 15,000 tons of coal may be stored within the range of a second grab crane. Fuel from the boiler-house bunkers is fed by gravity to the mechanical stokers. From the ash hoppers the ashes are discharged into skips mounted on rail bogies and the loaded skips are then lifted by means of an overhead telpher, and discharged into a main hopper, the contents of which are subsequently removed for disposal. Each boiler is equipped with a forced and an induced draught fan, and coal-recording meters automatically measure the fuel input to each stoker. Instruments on a steel panel in front of each boiler measure the usual quantities in connection with steam and firing conditions. The boiler-house is in two sections, with the operating gangway of the firing floor at right angles to the longitudinal axis of the turbine-room.

The original three main turbines are single-cylinder impulse-reaction machines. Each exhausts into a surface condenser of 15,000 square feet cooling surface. The condensate is withdrawn by duplicate turbine-driven pumps and is passed through various feed heaters to a de-aerating plant, and thence to the suction bus-pipe of the boiler feed pumps. The auxiliary turbines exhaust into a common bus-pipe and the low-pressure steam is used for feed heating. The feed-heating system raises the temperature of the condensate to 185 deg. Fah. For the original boiler plant four feed pumps, each with a capacity of 300 gallons per minute when operating against a total head of 800ft., were installed. The exhaust steam from these pumps is also used for feed heating. About 100 yards from the main station building a separate pump-house was erected for an initial installation of three vertical-spindle motor-driven centrifugal circulating pumps, each having a capacity of 14,000 gallons per minute when operating against a total head of 50ft. The circulating water intakes consist of three circular-section vertical shafts situated in the open sea, 1576ft. from the pump-house. Each intake is covered at the upper end with a built-up bar type grating, with 3in. spacings to obstruct large fish and wreckage. To ensure that the intakes are always submerged, they have been placed 4ft. below the lowest recorded spring tide. Each vertical intake connects with a horizontal tunnel, 57in. in diameter, which conveys the water to a point 65ft. below the pump-house main floor, and from that point three vertical shafts of 9ft. in diameter and fitted with screening chambers, extend to the pump-house level. To these shafts the pump suction and circulating return pipes are connected through electrically-operated valves. Four pipes, 42in. in diameter, form a connection between the pump-house and the turbine room, two for delivery and two for discharge. Sectionalised pressure and discharge bus-pipes are carried on cast supports throughout the entire length of the station, and connections are taken off them to the condensers. Since the sea intake and discharge shafts are always submerged, advantage is taken of the syphonic action obtainable in the closed system, and air pumps are connected to the pipe work at the condenser outlets.

The three-phase generators deliver current at 6600 volts. The neutral point is connected to earth through a resistance of 4·5 ohms. Cooling air is drawn from the turbine room basement through "Ventex" air filters by means of fans mounted on the generator rotors, whilst the heated air is discharged to the boiler-house basement, where the intakes to the forced draught fans are situated. The extra-high tension cellular switchgear is motor operated. There are duplicate sets of three-phase bus-bars while the switches on all the machines and main feeders are in duplicate. Low-tension current for auxiliary services is provided by four 1000-kVA, 6600/400-volt transformers, which also supply a local alternating-current network. For pilot lighting and for the operation of the control circuits of the extra high-tension switchgear and for a few special motors in the works, a 480-volt, three-wire battery was installed.

During the years following the war the demand for electrical energy increased at a phenomenal rate, and in 1924 it was necessary to order another 12,500-kilowatt turbo-generator, which, together with additional boilers, auxiliary plant and switchgear, was installed in 1925. In the same year a 5000-kilowatt set was reconditioned and transferred from the McDonald-road station to Portobello. This brought the capacity of the Portobello station up to 50,000 kilowatts, and completed the first section of the station. Careful estimates of the growth of the load indicated that by the year 1928 another generating unit would be required to cope with the demands of the Edinburgh system. As the existing building at Portobello could not accommodate more plant, the extensions involved civil engineering work associated with the preparation of adequate foundations and the construction of a new building, together with additional sea work and coal sidings. Plans for the foundations and structural work were prepared in 1925, and while the preliminary work of clearing the site was in progress in 1926 the Electricity Supply Act was passed. Working in close co-operation with the Electricity Commissioners and the Central Electricity Board, the Corporation decided to install two Brown-Boveri turbo-generating sets—see Figs. 1 and 2—with a maximum continuous rating of 31,250 kilowatts, together with additional boilers, switchgear and auxiliaries. The floor space necessary to accommodate these units represented approximately two-thirds of the remaining area of the site. In view of the probable future requirements of the Central Electricity Board, it was decided to construct the whole of the foundation raft necessary for the station in the final form in one operation, and to confine the building and structural work to that required for the plant to be installed. The general plan of the extension follows the same sequence as that of the original building, viz., from front backwards—switch-house, turbine-house, and boiler-house.

On account of the increased quantity of circulating water required for cooling purposes, it was necessary to augment the facilities for the handling of sea water. A fourth sea tunnel was, therefore, driven, the sea end consisting of a vertical shaft 9ft. in diameter and situated 1625ft. from the pump-house. A horizontal tunnel 8ft. 6in. in diameter connects this shaft with a vertical 8ft. 6in. land shaft situated near the pump-house, and a breeches pipe connects the top of this land shaft to two 72in. culverts, which are connected at the power-house end to the circulating water discharge bus-pipe in the pipe annex to the turbine room. While it is intended to use this new tunnel for discharge purposes only, provision has been made for connecting it to the suction side of the circulating pumps if necessary. Two new vertical-spindle circulating pumps, each capable of dealing with 30,000 gallons of water per minute and driven by 625 B.H.P. motors, have been installed in the extended pump-house. The pipe work between the pump house and the station has been augmented by a 48in. pressure pipe and a 42in. discharge pipe. An additional 60in. pressure pipe has also been laid and is divided into two 48in. branches at a suitable point. The connection between one branch and the circulating water bus-pipe in the annex has been completed, while the remaining branch, which will supply the final extension of the station, is at present blanked off.

The original coal sidings comprised 900 yards of single track, and in order to provide adequate facilities for the marshalling of both full and empty trucks, it was decided to put down an additional 1800 yards of single track, an undertaking which necessitated the construction of a new railway tunnel under the Portobello-road. With the new siding facilities it is possible to unload coal at the rate of 1000 tons per day. Additional coal-handling plant has also been installed to deal with the increased fuel consumption. It consists at the coal sidings of three new capstans for haulage purposes within the sidings, a new weigh-bridge and a rotary wagon tippler with the necessary coal hopper. The conveying plant consists of a complete system of belts and elevators capable of feeding all the boiler-house bunkers in the old and new sections. A duplicate feed to every coal bunker in the station is now available. The main conveyors and elevators of the new system have a carrying capacity of 100 tons per hour, and the sub-conveyors a capacity of 60 tons per hour. The elevators are of the belt-bucket type, whilst the cross conveyors over the bunkers are of the push-plate, or scraper, type.

In each of the two new boiler houses, the steam generating plant consists of four tri-drum units with integral superheaters, tri-drum economisers and air heaters. Four of the new boilers are designed for a continuous output of 80,000 lb. per hour, and four for an output of 90,000 lb. per hour. The steam conditions correspond with those of the original boilers, viz., a pressure of 300 lb. per square inch and a total temperature of 700 deg. Fah. All the boilers in the extension are fitted with chain grate stokers and Cope's feed water regulators. Fuel is fed under gravity to the stokers from overhead bunkers of 300 tons capacity per pair of boilers, and the weight of coal used per stoker is recorded automatically. On

FIG. 3—MAIN METAL-CLAD SWITCHGEAR

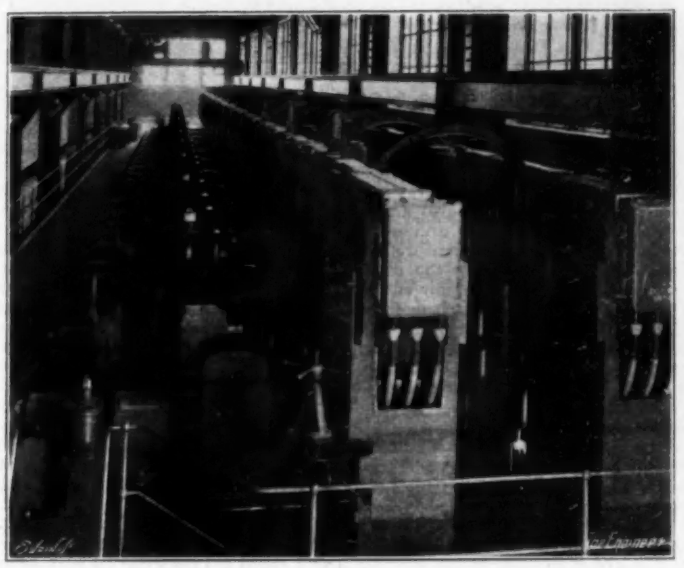


FIG. 4—GENERAL VIEW OF MAIN SWITCHGEAR

their way to the chimney the products of combustion pass through grit arresters. Forced-draught fans draw air from the fan rooms and pass it through air heaters in which the temperature is raised to approximately 250 deg. Fah. There are also induced-draught fans which, like the forced draught fans, are electrically operated at various speeds. Ashes are removed from the hoppers in bogie-mounted skips and are conveyed to the collecting hopper by means of telphers. For each boiler there is a set of indicating instruments mounted on a panel at a convenient height above the firing floor. The instruments give visual indications of the steam pressure, temperature and output in pounds per hour, the economiser water inlet and outlet temperatures and rate of feed, the flue gas economiser inlet and outlet temperatures, the air heater outlet temperature, the CO_2 concentration in the gases leaving the economiser, and the temperature of the heated air entering the furnaces. There are also gauges for the forced, induced and balanced draught and recording instruments for all the steam and water quantities, as well as a CO_2 recorder. In each boiler-house there is an indicator showing the total electrical load on the station. Four steam-driven and two electrically-driven boiler feed pumps, each with a capacity of 20,000 gallons per hour, and two de-aerating units each capable of reducing the oxygen content of 600,000 lb. of condensate per hour from 2 to 0·05 c.c.s./litre, have been provided.

The two new turbo-alternator sets have each been designed for a maximum continuous output of 31,250 kW at 0·8 power factor and run at a speed of 1500 revolutions per minute. The turbines are of the three-cylinder type with double exhausts, and there are two separate condensers for each set. Each turbine is equipped with two steam chests, to which steam is supplied through two 12in. pipes. The chests are supported on the turbine room steelwork and are coupled to the high-pressure cylinder through four U-shaped pipes, and any distortion owing to the expansion of the 12in. pipes is confined to the steam chests and U-pipes. As the steam passes through the high-pressure and intermediate-pressure cylinders in opposite directions and as the low-pressure cylinder is also balanced owing to the central inlet and double exhaust the axial thrust of the complete set is balanced. Each surface condenser has a cooling surface of 16,140 square feet, and the steam space in the two condensers is connected by a balance pipe. Duplicate three-stage steam jet ejectors are provided for air extraction. The condensate extraction pumps are also in duplicate. One of these pumps is driven by an electric motor and the other by a steam turbine. The condensate discharged from the pumps passes through surface heaters on the air pumps, then through a bleeder heater at the outlet of the intermediate-pressure cylinder and thence to the de-aerating plant. As each condenser is of the two-pass type, the inlet and outlet circulating water connections are at the same end. The connections are completed through valves and expansion joints to the water bus-pipes situated in the pipe annex. At each end of the condensers there is a hinged davit on which the condenser end covers may be supported and removed to enable the condenser tubes to be inspected or cleaned.

The three-phase alternators are wound for 6600 volts between phases, and the neutral points are connected to earth through remotely-controlled oil switches and a 4·5-ohm limiting resistance. The machines are ventilated on the closed system, the air circulation being provided by fans mounted at opposite ends of the rotor. The tubular air coolers are supplied with sea water from the circulating system. Thermo-couples situated at different points in the stator slots give direct readings of the temperature rise. The stator windings are equipped with Merz-Price circulating current protection, and on the operation of this gear a field suppression switch automatically cuts off the excitation from the machine and short circuits the rotor winding through a resistance of low ohmic value.

The main switchgear—see Figs. 3 and 4—is of the metal-clad compound-filled type with duplicate bus-bars. Complete phase separation has been obtained by assembling each phase bus-bar in a separate metal enclosing trunk and by providing independent tanks on each phase of the main oil circuit breaker, the bus-bar selectors and cable isolating switches. There are therefore twelve tanks per three-phase unit, requiring 980 gallons of oil in all. The main cylindrical oil circuit breaker tanks are composed of ¾in. welded steel plate and are secured by means of eight 2in. bolts. The rupturing capacity of each circuit breaker is 1,500,000 kVA. The main circuit breakers, selectors and isolators are solenoid-operated and a very complete interlocking system not only prevents the incorrect sequence of operations, but also ensures that no tank can be removed until the copper work about to be exposed has been made dead, and when a tank has been lowered it is impossible to make the switch associated with that tank alive. The main generator switches are designed to carry 3500 ampères continuously, the weight of each three-phase unit complete being 31 tons. The main operating control board is shown in Fig. 5. As it is intended to divide the Edinburgh system into two sections, each supplied from one set of bus-bars, a set of 2000-ampère reactors has been installed as bus-bar couplers to localise the effect of a disturbance on either section. By means of suitable switching arrangements, however, these reactors may be isolated or short-circuited when desired. The auxiliary switchgear shown in Fig. 6 is also metal clad gear, but the switches controlling the main circuits are manually operated and are arranged for automatic tripping on the operation of the overload protective devices. All sub-circuits are controlled by means of metal-clad switch and fuse units.

The extensions were carried out to plans prepared by Mr. Edwin Seddon, engineer and manager to the Edinburgh undertaking. The foundations and buildings were constructed to the designs and specifications of Mr. E. J. MacRae, the City Architect, with the co-operation of Macdonald and Partners and Mr. George Fraser. The sea tunnel and shafts were constructed to the designs and specifications of J. and A. Leslie and Reid, and the sidings to plans and specifications prepared by Mr. W. A. Macartney, the Borough Engineer, the work being supervised by Mr. E. Barnard. The principal contractors employed on the extensions at the Portobello station were as follows:—

Raft, buildings, culverts and coal sidings: John Angus and Sons.
Reinforced concrete work in boiler-house: Stuart's Granolithic Company, Ltd.
Structural steel work: Redpath, Brown and Co., Ltd.
Sea work: John Best (Edinburgh), Ltd.
Circulating water pumping plant: W. H. Allen, Sons and Co., Ltd.
Coaling plant: Babcock and Wilcox, Ltd., and Ritchie-Atlas Engineering Company.
Electric capstans: James A. Liddle.
Boiler-house coal bunkers: Caledon Shipbuilding and Engineering Company.
Boilers and economisers: Stirling Boiler Company, Ltd.
Chain-grate stokers: Babcock and Wilcox, Ltd., and Underfeed Stoker Company, Ltd.
Air heaters: Carrier Engineering Company, Ltd., Babcock and Wilcox, Ltd., and Underfeed Stoker Company, Ltd.
Grit arresters and fans: Davidson and Co., Ltd.
Flue dust extraction plant: Pneumatic Conveyance and Extraction (1929), Ltd.
Ash telphers: General Electric Company, Ltd.
Boiler feed pumps: Mather and Platt, Ltd., and Harland Engineering Company, Ltd.
Steam and water pipe work: Aiton and Co., Ltd., John Spencer, Ltd., Brightside Foundry and Engineering Company, Ltd.
Steam valves: Dewrance and Co.
Water valves: Glenfield and Kennedy, Ltd., and J. Blakeborough and Sons, Ltd.
De-aerating plant: W. H. Allen, Sons and Co., Ltd., and Mirrlees-Watson Company, Ltd.
Turbo-alternators: British Brown-Boveri, Ltd.
Condensers and air pumps: W. H. Allen, Sons and Co., Ltd.
Main and auxiliary switchgear: Metropolitan-Vickers Electrical Company, Ltd.
Auxiliary motors: Bruce Peebles and Co., Ltd., English Electric Company, Ltd., and British Thomson-Houston Company, Ltd.

The cost of the recent extensions amounts to £13·2 per kilowatt of plant installed, and the cost of the whole station to date is £17·7 per kilowatt.

FIG. 5—CONTROL BOARD

FIG. 6—METAL-CLAD AUXILIARY SWITCHGEAR

The International Railway Congress.

No. III.*

SUBJECT VI.—IMPROVEMENTS IN THE STEAM LOCOMOTIVE.

REPORT No. 1 under this heading refers to France, Italy, Portugal, Spain, and their colonies, and is by Mr. A. Parmantier, assistant chief mechanical engineer, Paris, Lyons and Mediterranean Railway.

The reporter divides his subject under seven headings:—(1) Increase in boiler pressure; (2) superheating of the steam, (*a*) increase in the degree of superheat, (*b*) improvements in the design of superheaters and in those parts which are connected with the application of superheating; (3) feed-water heating; (4) air preheating; (5) valve motion; (6) draught and exhaust; (7) miscellaneous.

The conclusions of the reporter as to an increase in the boiler pressure is that it can be increased from 228 lb. per square inch to 284 lb. per square inch without difficulty. Under that heading the use of special steels in the construction of boilers is to be kept in view. The increase in the boiler pressure is as valuable for single-expansion as for compound locomotives. In respect to superheating, the conclusions are that temperatures of the order of 752 deg. Fah. for compound locomotives and 662 deg. Fah. for simple expansion locomotives ought to be used generally.

The heating of feed-water by exhaust steam is a practical method for appreciably improving the efficiency of locomotives. Closed type heaters tend to be used in place of the open type. Various types of feed-water heaters are in existence, which are giving satisfaction, but there is no particular design clearly superior to the others, which should be adopted generally. The question of weight may be the determining factor when selecting a design of equipment. Feed-water heating by the combustion gases is, so far, still in the experimental stage. None of the railways covered by the reporter has carried out tests on the preheating of the air supplied to the fire-box. That improvement has only been applied, as far as the reporter is aware, to engines of new types like the Ljungström turbine and the Winterthur high-pressure locomotive.

On the subject of valve motion, the opinion is expressed that long valve strokes improve the efficiency of locomotives and enable them to run more freely at high speeds. The conjugation of the motions has substantial advantages from the point of view of construction and maintenance, and is of special value

* No. II. appeared May 2nd.

for simple expansion locomotives. Poppet valve gears are being increasedly used, at least for trial. In relation to draught and exhaust it is recorded that improvements in the efficiency of the blast-pipe and front end arrangement have been the object of many trials. Good results have been obtained by using multiple cones and petticoat pipes.

Under the heading Miscellaneous, it is recorded that since the Rome Congress none of the railways under review has carried out methodical tests with a view to comparing simple and compound locomotives. Another item of interest is that to reduce the wear of tire flanges and of rails on sharp curves, many companies have endeavoured to lubricate either the flanges or the rails. Very good results therefrom are reported from the Southern (Midi) of France and the Paris, Lyons and Mediterranean railways.

To Mr. Theodore Bals, of the Roumanian State Railways, was given the duty of dealing in Report No. 2 with all countries except America, the British Empire, France, Italy, Portugal, Spain, China, and Japan. Mr. Bals opens by observing that since the Rome Congress there has been no notable change as regards the boiler pressure adopted as a general rule for the boilers of both simple expansion and compound locomotives. For simple expansion locomotives the pressure varies from 170 lb. to 200 lb. per square inch; the latter figure appears to be becoming more and more general, especially for the powerful locomotives constructed during the last few years. Higher boiler pressures are only met with as exceptions; for example, the Roumanian State Railways possess sixty-five two-cylinder simple expansion locomotives, which were built in America, the boiler pressure of which is 213 lb. per square inch. For compound locomotives pressures of 213 lb. to 228 lb. per square inch are the most general, and no administration has reported any pressure higher than 228 lb. per square inch.

In his final summary Mr. Bals remarks on the subject of superheating that there is a tendency to increase present-day temperatures in order to obtain the maximum fuel economy within the limits imposed by the efficient lubrication of the parts in contact with the steam. It would appear, he says, that the limit is now in the region of 720 deg. Fah. In general, superheaters with large tubes are preferred; however, a number of administrations have also adopted superheaters in tubes of small diameter, and state that they are satisfactory and that no serious difficulty has been experienced in keeping the tubes clean. One conclusion arrived at is that it does not seem necessary to have a pyrometer on a locomotive.

The reporter for America, Report No. 3, is Mr. W. L. Lentz, motive power engineer, New York Central Railroad, who opens his review by the statement that—

> There have been such extraordinary developments in the steam locomotive that the railroads of the United States have, during the last eight years, spent six and a-half billion dollars for new and improved equipment, with which, during 1928, they have attained the greatest operating efficiency and economy in their history. This increased operating efficiency took place in the face of reduced traffic during the first ten months of that year.
>
> Fewer trains and locomotives, in proportion to the amount of traffic hauled, were required in 1928 than ever before. The average load per train was the highest ever reported, having been 2·6 per cent. greater than in the first ten months of 1928 than in the same period of 1927. The distance travelled each day per freight train averaged 307 miles, an increase of approximately 20 per cent. over that of 1923, when the average was 259 miles. The number of tons of freight moved one mile by a train per hour was greater in 1928 than ever before. Freight traffic in 1928 was hauled with the greatest conservation of fuel ever reported; coal consumption per 1000 gross ton-miles was 125 lb., which compared with 129 lb. in 1927.

The majority of new locomotives in all classes of service constructed during the period under review have boiler pressures ranging from 210 lb. to 250 lb. per square inch. At the present time there are 1500 locomotives carrying boiler pressures of 225 lb. and upwards; more than 50 of them use pressures between 265 lb. and 284 lb. per square inch. There are no indications that the use of higher boiler pressures has resulted in any appreciable increase in maintenance cost, nor has there been any material change in design in boiler fittings which can be attributed primarily to increased pressures. Higher superheats have been coming into use and are being demanded by the railways in practically all cases when new designs are being considered.

Two Canadian roads are doing considerable development work in connection with the use of alloy steel in the construction of high-pressure boilers. One has forty locomotives, and twelve additional on its subsidiary line, in which use is made of silicon steel for the construction of boilers. This steel shows an average tensile strength of about 76,800 lb., and a yield point of about 16,100 lb. The use of it has permitted an increase of boiler pressure from 200 lb. to 250 lb., with little change in design, size, or weight. Similar results are obtained by these roads with forty-four locomotives using 250 lb. pressure, in which the boiler shells are constructed of nickel steel. This steel shows an average tensile strength of 76,700 lb., with a yield point of 59,200 lb. That represents a gain in strength of about 29 per cent., as compared with the carbon steels usually employed. Mr. Lentz says it is evident that the use of alloy steel and steel stays will contribute to the successful use of pressures, within the foregoing range, in conventionally stayed boilers.

On the subject of superheaters, it is observed that there are 49,000 locomotives in America equipped with fire-tube superheaters. Of these, 25,500 were built with superheaters and the remainder were converted.

Associated with the question of superheaters, is the development of the multiple valve regulator, built integral with the superheater heading—see THE ENGINEER, March 23rd, 1928. Thereon the reporter says:—

> More than 1000 locomotives have been fitted with the multiple throttle, the use of which is increasing very rapidly. There is quite general acceptance of the idea that the throttle valve should be located between the superheater and the steam chest. The benefits accruing from such an arrangement on a locomotive are that the throttle and its operating rigging are removed from inside the boiler and outwardly made accessible with less difficulty. The handling of the locomotive is improved, as the control of the steam is much closer to the steam chest valve, and this advantage in handling is particularly noticeable for freight and passenger train service. To build a throttle integrally with superheater heading has many admitted advantages in weight, space required, number of steam pipe joints in the smoke-box and, in the form of the multiple throttle, provides a valve which, being smaller in diameter, remains tight, is easily inspected, manipulated and maintained and, by providing opening, in series, of the several valves, permits a closely graduated flow of steam.

Preheating of boiler feed water increases the maximum evaporative capacity by 12 to 15 per cent. and the combined efficiency of the boiler by at least 10 per cent. For equal capacities it makes it possible to decrease the weight of the boiler by 12 to 14 per cent., and the available water supply is extended by 15 per cent. It decreases the cost of the boiler maintenance, because 15 per cent. of the feed-water is returned in the form of condensed steam or distilled water.

Air preheaters have not yet been applied to locomotives in the United States. In the past sporadic attempts have been made to preheat combustion air, but, as far as the reporter knows, they have not proved successful, and the apparatus has been removed.

Report No. 4, for the British Empire, China, and Japan, is by Mr. H. N. Gresley, and the outstanding feature of it is that 78 pages out of a total of 131 pages are given up to the replies to the reporter's questions. They cannot, of course, even briefly, be summarised.

In the text of his report Mr. Gresley relates that the Great Northern (of Ireland) records the use of increased pressure on existing engines. Eight 4–4–0 express locomotives have had their pressure increased from 170 lb. to 200 lb. per square inch, and the London and North-Eastern, for comparative purposes, fitted fifteen 4–6–2 express locomotives with boilers having the working pressure increased from 180 lb. to 220 lb. per square inch, in order to gain knowledge of the relative maintenance and operating costs of similar engines working at those respective pressures. The former company reports no noticeable difference in fuel or water consumption; the L. and N.E.R. results are given at length in a table in which we notice that the consumption of coal per mile was 37·0 lb. for the 220 lb. locomotive, against 40·6 lb. for the 180 lb., and the evaporation in pounds of water per pound of coal was 8·17 as against 8·2.

For all the railways reporting, the increase of boiler pressure

> appears to have produced economy in fuel and water consumption. At the same time it is reported that there is an increase in the cost of maintenance of fire-boxes, which may go so far as to neutralise the economies effected in fuel consumption. It is desirable, therefore, that further experience as a result of increasing the boiler pressure should be obtained.
>
> Higher pressures have resulted in more powerful locomotives being built within the gauge limits, and this is of special value when it is required to provide more powerful locomotives than those which have been built to the extreme limits allowed by the gauge.

No railway reports experiments in connection with the use of higher superheat—*i.e.*, above 700 deg. Fah. That appears to be the highest temperature that can generally be regarded as satisfactory in locomotive work, although some companies have recorded as high as 800 deg. Fah. With temperatures not exceeding 750 deg., there is no difficulty with packings and lubrication, and consequently that figure should not be exceeded with standard designs. In 1926 the London, Midland and Scottish Railway fitted up 200 engines for oil burning, wherein the superheat often reached nearly 800 deg. Fah. There was difficulty with piston-rod packing, owing to the high steam temperature, but it was overcome by changing the white metal, of 70 per cent. lead and 30 per cent. antimony, to a special bronze alloy packing, of 96 per cent. copper, 2 per cent. antimony, and 2 per cent. aluminium.

The impression conveyed as to the use of pyrometers is that they serve no really useful purpose in ordinary working and consequently need not be fitted as a general rule.

The conclusions as to the remainder of the subjects covered by Mr. Gresley may be judged from the following summary:—

> Feed water heaters, of the exhaust type, are most widely used. Those of the open type are becoming more widely adopted owing to their increase in efficiency.
>
> The introduction of poppet valves as a means of steam distribution is increasing. There is a marked tendency with piston valves to give more lap on valves with longer valve travel.
>
> There is no standard design of smoke-box layout. Efforts have been made with blast-pipe arrangements to improve the blast and to reduce back pressure. The improvement in engine efficiency has resulted in the smoke not being lifted clear of the boiler. Several experiments are being made to remedy this, and some re-design of the front end may be necessary to overcome the difficulty.
>
> Compounding is not being extended except on a few railways using Mallet engines.
>
> The usual arrangements of ashpan and dampers, brick arch and fire-hole door meet all requirements.
>
> There is a marked tendency towards the adoption of regulators of the double-beat balanced type.
>
> Steam dryers have met with little success.
>
> Soot blowers have been widely introduced, and labour in tube cleaning at locomotive depôts has been reduced.
>
> Boosters have been introduced in two countries only and have given satisfactory results.
>
> The use of special alloy steels for coupling rods and motion parts is becoming more general and has effected a reduction in weight of reciprocating and revolving parts. The results obtained are entirely satisfactory and have contributed to improve engine balancing.
>
> No railway reports the use of light alloys.

Report No. 5 is for Germany, and by Mr. R. P. Wagner, of the German State Railway Company, who opens his remarks by saying that the Reichsbahn has had a special opportunity of making progress during the last few years, by reason of the necessity for dealing with the operating and economic handicap imposed on them by a collection of locomotives of the most varied types, from a large number of hitherto independent lines. Standard locomotives, of the most modern design, with as few types as would be consistent with economical working of the extensive network of lines, were required. Standardisation of the rolling stock as a whole, and of component parts, manufactured on an interchangeable basis, with tolerances to suit operating and workshop conditions, has led to the production of locomotives embodying the very latest ideas in modern construction.

Proceeding, the reporter says:—

> On the Reichsbahn we consider the question of improved energy transformation along two entirely separate lines, both of which have been followed up with equal vigour. First, there is the development of entirely new types by adaptations from stationary machines—such as increasing the pressure to the highest possible figure; the use of the turbine and, with it, of condensing; pulverised fuel; the Diesel engine. Secondly, there is the systematic development of the old types, as in the case of the standard locomotives already mentioned. Opportunities for effective and appreciable progress in this direction have been limited during the last thirty years. Compounding, superheating and feed water heating have certainly justified themselves by considerable savings in consumable stores, but further success is still possible by giving attention to many apparently small details.

More than ten years ago the prevailing boiler pressure was 170 lb. per square inch, but the standard to-day is 200 lb., and in some cases 228 lb. per square inch. The increase has not yet reached its limit, although pressures above 228 lb. bring difficulties with ordinary boiler materials, owing to questions of weight, unless, of course, an engine with greater heat efficiency is employed, in which case, to start with, the boiler can be smaller.

The remainder of the report is of a general but highly technical character, and almost wholly devoted to superheat. Added to that there is the disadvantage, when attempting a summary, that the report does not close with the usual "conclusions," which, actually, are the reporter's recommendations. All that we can offer is the synopsis which precedes the report. That reads:—

> Possibilities of improvement by elaborating the theoretical principles, by further developing existing details and by perfecting constructional methods.
>
> Increasing the pressure in normal locomotive boilers. Raising the degree of superheat. The progress of superheater design and the basis of the present form.
>
> Suggestions for the more accurate determination of boiler dimensions. Adaptation to superheating of other parts, such as regulators, valves, pistons, cylinders, pressure equalisers, &c. Economy in steam consumption. Principles to be observed in regard to valve motion. Simple and multiple expansion two and three-cylinder simple locomotives.
>
> Progress in methods of lubrication to meet the increase in steam temperature.
>
> The heating of feed water by combustion gases and by exhaust steam. Development of accessories required with feed water heating. Recovery of condensate. Sludge separators.

We must, however, quote in full the reporter's concluding remarks, wherein he refers to the influence of more highly developed methods of manufacture and maintenance. He says:—

> A discussion of the improvement of normal locomotives, by increasing their thermal efficiency, by the use of more satisfactory components and by other means, would not be complete without reference to the influence of more highly developed methods of manufacture and maintenance. Much detail work has been devoted to this subject during the last few years. Consider, for example, only the production of new locomotives. By specifying tolerances, which cover all the principal dimensions of a part, and by expert supervision manufacture is now on such a basis that interchangeability can be guaranteed.
>
> Tolerances are issued as complete instructions, and the observance of these instructions, together with inspection extending to each individual tolerance dimension, are, at the present time, matters within the purview of the locomotive work administration as part of the fulfilment of their task. The introduction of these methods has contributed to making the standard engines built under it, and in which are incorporated the other improvements covering the individual components, the most economical and serviceable machines in the depôts of the Reichsbahn.

SUBJECT VII.—ELECTRIC LOCOMOTIVES FOR MAIN LINE TRACTION.

Report No. 1, under this subject heading, deals with France and the French Colonies, and is by Messrs. de Boysson and Leboucher. The former is the chief mechanical engineer of the Paris–Orleans Railway and the latter the chief engineer of the rolling stock and locomotive running department of the Midi of France Railway.

It is observed that the experience on the Midi and the Paris–Orleans is that it is possible to attain with well-designed machines 55·9 m.p.h. and over, but that such speeds on cheaply maintained lines can lead to rapidly increasing maintenance expenses, and, in

fact, it is better not to exceed a speed of 50 m.p.h. with this type of locomotive, except on very good tracks and with specially designed engines.

The most common type to be found in France is the "B.B." (0–4–4–0) designed by the Constructions Electriques de France at Tarbes. There are 230 engines of this type on the Midi, 16 on the Paris–Orleans, 10 on the Paris, Lyons and Mediterranean, and 26 in Morocco. The report says that they run very steadily. On the Paris–Orleans they have been driven up to 68·3 m.p.h.; on the Midi the heating up of the motors has prevented such speeds being attained.

In addition to the 16 mentioned above as on the Paris–Orleans, that system has a further 184, or 200 in all, of the "B.B." type, of which 80 were supplied by the Société des Etudes pour l'Electrification des Chemins de Fer; 80 by the Groupement Société des Batignolles—Société Oerlikon; and 24 by the Société Alsacienne. All three types can be driven in the normal way up to speeds of 55·8 m.p.h. without inconvenience; however, the Batignolles–Oerlikon type, which has proved to be the most stable, is given preference on workings requiring those speeds.

The Paris, Lyons and Mediterranean has ordered 30 locomotives of the "I.C.C.I." (2–6–6–2) type; ten from the Compagnie Electro-Mécanique et Fives-Lille; ten from the Constructions Electriques de France and the Société Alsacienne; ten from the Société des Etudes. Beyond stating that these locomotives have been ordered, there is no information as to the results. The last-named firm is said to have designed a locomotive of the same type, which can run at 68·3 m.p.h. The State Railways possess 30 locomotives of the "B.B." type, but, again, no particulars are given as to their working. The Paris–Orleans has also two of the "2 D 2" or 4–4–4–4 type, built by the Ganz Company, and two, with the same wheel arrangement, supplied by the Brown-Boveri Company.

Ten locomotives of the "2 C 2" type, built by the Constructions Electriques de France, for the Midi Railway, are reported to run remarkably steadily up to a speed of 89·5 m.p.h., the maximum reached under test. The Paris, Lyons and Mediterranean has ordered six high-speed locomotives—two of the "2 B.B. 2" type and four of the "2 C.C. 2." One of the former is a Batignolles-Oerlikon and the other was built by the Société Alsacienne; the four "2 C.C. 2" are also of the Batignolles-Oerlikon type, which, it is said, should run at a speed of 80·8 m.p.h.

Messrs. de Boysson and Leboucher conclude their report as follows:—

> Locomotives, with motors supported by the nose, are very satisfactory for all services in which the maximum speed does not exceed 50 m.p.h., and, in exceptional cases, 55·9 m.p.h.; it has even been possible, with suitable gear ratios, to run up to 62 m.p.h. The locomotives run very steadily when out on the line, up to that speed; however, the actual experience of the French railway companies is that it is not possible to be sure that different parts of the locomotive, especially the motors, will not suffer at such high speeds and result in heavy upkeep expenses. These locomotives have the advantage of being moderate as regards upkeep and first costs.
>
> For higher speeds it is necessary to use locomotives with the motors fully spring-borne, which are more costly and complicated. Satisfactory results have been given by various types, but there has not been sufficient experience for any one to be selected as the best. The only locomotive with the motors not spring-borne—a gearless "2 C.C. 2" locomotive built by the General Electric Company for the Paris–Orleans—has not been in service long enough for any definite opinion to be expressed upon it; it has the benefit of very great simplicity, but nothing can yet be said about its behaviour on the track.

Report No. 2 relates to America, and is by Mr. J. V. B. Duer, of the Pennsylvania Railroad. It fills 136 pages, and is the longest document we have had to deal with; even the summary fills nearly eight pages.

Taking only the summary, we note that it is remarked that the greater portion of recent installations of electric motive power equipment has consisted of electric locomotives designed primarily for freight service, many on heavy mountain gradients. The majority of them have been designed to operate on the single-phase alternating-current system. It is accordingly in that field that the greatest developments have taken place. In the mechanical design of electric locomotives, features of special interest are found on the "Mountain" type of heavy freight locomotives on the Virginian, the heavy freight locomotives on the Detroit, Toledo and Ironton, the "Mountain" type freight locomotives on the Great Northern and on the Mexican, and the new freight locomotives for the New York Central. Recent advances in electrical design are illustrated by the split-phase alternating-current Virginian locomotives and the motor generator locomotives on the Great Northern, the Detroit, Toledo and Ironton, and the New York, New Haven and Hartford.

After a reference to multiple-unit cars for suburban services and to the changes made in the equipment of electric locomotives, it is remarked that, owing to the need for heavier and more powerful locomotives, the total weights have increased and reach a maximum of 640 (short) tons on these latter locomotives. The heaviest type of single-unit locomotive, recently placed in service, is the 259-ton motor generator locomotive on the Great Northern. With a tendency toward a smaller number of high-powered driving wheels on each unit, increased axle loadings in which the track structure is capable of withstanding the higher stresses have resulted. The present maximum axle weight is 77,000 lb. on the Virginian freight locomotives, while the Great Northern freight locomotives have a loading of 70,000 lb. per driving axle.

For the British Empire, China and Japan, Messrs. Asakura and Imaidzumi, of the Japanese State Railways, have prepared Report No. 3, wherein it is said that the reporters were assigned to receive data from the countries named, but—

> this data is so meagre that, as yet, there is no reliable foundation on which to base a discussion as to electric locomotives. No type is standard or in common use, nor is any one type acknowledged to be the best. Therefore, many problems concerning electric locomotives still remain for solution. Some of these problems may be common to all types. But some problems that have developed should be investigated individually, in accordance with the system of electrification employed. Such wide investigation is, however, beyond the scope of this report, and therefore we shall confine our remarks mainly to the conditions in Japan.

Besides about 500 miles of local lines, the property of private companies, which are operated by electric locomotives, there are two sections of the Government Railways. One is on the Tokaido main line, near Tokyo, 62 miles in length, carrying a dense traffic and operated on a 1500-volt direct-current system. The other is a short rack railway on a gradient of 1 in 15.

The main feature of the reporters' conclusions is contained in the following remarks from the opening of the summary to their report:—

> General data on electrified railways and their locomotives were gathered from the British Empire, China and Japan. The electrified sections are not as yet very extensive. Usually the system of electrification is direct-current, the voltages being different. The locomotives are mostly of the nose-suspended, single-gear type. The Japanese Government Railways, with many of this type, have found that it is quite satisfactory so far as the locomotive itself is concerned. Its effect upon the maintenance of the track is different, dependent upon whether or not the locomotive is equipped with a well-designed leading truck.
>
> From the results of the tests which have been carried out, we conclude that generally the nose-suspension type, with a leading truck, attacks the track less than a steam locomotive, while the attack of the locomotive, without a leading truck, is greater. That the amount of flange wear of the driving wheel tire of the former is less than that of the latter is another evidence that a good leading truck is an important factor, even for locomotives of medium speed as well as for those of high-speed services. The simple and solid construction of this type is also preferable, and it affords ample room for its equipments. Thus, the nose-suspension type, with a leading truck, is regarded as a desired one for direct-current locomotives.
>
> The individual axle drive type, of a proper design, is also a good type. But there it is rather difficult to arrange the machinery and apparatus in such a way as to be quite convenient for inspection in the case of the employment of the high-tension direct-current system.

For all countries, except America, the British Empire, China, Japan, France and the French Colonies, Mr. Guiseppe Bianchi, inspector-in-chief in the rolling stock and traction service of the Italian State Railways, presents Report No. 4. Nine administrations give particulars of the 1305 electric locomotives in all used on an aggregate of 5058 miles. The latter figure includes 1746 miles on the Italian State Railways, 1666 miles on the Swiss Federal Railways, and 916 on the Swedish State. Current on practically all the Italian mileage is 3700-volt, three-phase, and all the Swiss is 15,000-volt, single-phase, as is all the Swedish. The total of 5058 miles includes 2981 miles of 15,000-volt, single-phase, and 1365 miles—in Italy—of 3700-volt, three-phase. The 1305 locomotives are divided thus:—38 "very high speed," above 62 m.p.h.; 441 high speed, 46·6 to 62 m.p.h.; 140 up to 46·6 m.p.h.; and 686 locomotives, for goods or mountain traffic, from 31 to 40·4 m.p.h.

The conclusions arrived at by the reporter are that, as has, in fact, already been stated by the various reporters at previous Congresses, electric locomotives, although the date of their introduction into railway service is now some decades past, do not yet present, even in their general lines, that uniformity of design which the steam locomotive, on the contrary, presented even a few years after its invention.

(To be continued.)

Business Research and Management Association.

WE were invited to attend the final meeting of the 1929–30 session of the Business Research and Management Association of Great Britain, which was held in the evening of Thursday, May 1st.

This Association—the hon. secretary of which is Mr. H. A. Haylett, F.S.S., whose address is 50, Bushey-avenue, Snaresbrook, E. 18—was founded in 1924. It has for its dominant purpose the promotion and the more extensive use of research methods in the service of all branches of industry and commerce. It interprets the term "Research" more specifically in its application to problems relating to the marketing of all classes of merchandise and service, in their transit from the manufacturer to the consumer. Strictly technical—or laboratory—research does not come within its purview, which, however, embraces production, planning, budgetary and sales control, staff control, merchandising, marketing, advertising, sales policy, and the use of statistical and analytical methods as an aid to scientific management.

Among the leading objects of the Association are the advocacy of the collection of authoritative comparative data, and their careful analysis and application to particular problems. To that end, monthly meetings are held during the winter months of the year, at which papers, contributed by specialists in some phase of research or management methods, are read and discussed. During the session just completed papers on the following subjects were presented:—"International Research," "Budgetary Control and Sales Analysis," "Wastage of Labour in Industry," "Research as Applied to Sales Measurement and Sales Forecasting," "Costing in Relation to Industrial Stabilisation," and "Sales Quotas." All these papers had been prepared by men eminently capable of dealing with their particular subjects.

One of the meetings—on this occasion it was the last of the session—is preceded by the annual dinner of the Association, which is held, as indeed are all the other meetings, at Anderton's Hotel, Fleet-street, London, E.C. Nearly one hundred members and guests sat down under the chairmanship of Mr. W. Bayford Stone, F.C.A., the President of the Association. After the toast of "The King" had been honoured at the conclusion of the dinner, the Chairman called upon Mr. J. A. Crabtree, of J. A. Crabtree and Co., Ltd., Electrical Accessories Manufacturers of Walsall, to speak on "Research: The Foundation of Successful Business Building." Mr. Crabtree thereupon delivered a most able address, laying stress on the advantages to be obtained from, and, indeed, the paramount importance of studying and making research into every branch of a business. His remarks were illustrated by means of curves obtained in his own business, which, as the Chairman had explained at the outset, and before calling on him to deliver his address, had risen in eleven years from insignificant beginnings to employing 1000 men or so. Research, Mr. Crabtree maintained, should be made into raw materials, the best machines and methods to employ for given purposes, management, labour, production methods, &c., and might also be of service in attempting to forecast the future trend of business. It must, however, be employed with discretion, its findings must be accepted and acted on with courage, and care must be exercised in determining when it had been carried far enough. Many other points were discussed, and the whole formed a most interesting and well-thought-out address. A discussion followed.

B.E.S.A. SPECIFICATIONS.

RAILWAY SIGNALLING SYMBOLS.

THE British Standard Railway Signalling Symbols (Part I.), dealing with schematic symbols, has just been issued by the British Engineering Standards Association. The symbols are intended for use on general plans showing signalling requirements, and therefore none of them attempt to show the component parts of the apparatus to be used. They have been so designed that they may be combined with each other where one does not adequately represent the complete device. For convenience of reference, the symbols have been divided into the following seven sections and numbered, an alphabetical list being given at the end of the document:—Section 1: Signals, Semaphore and Light. Section 2: Points. Section 3: Track Details. Section 4: Apparatus. Section 5: Controls. Section 6: Level Crossings. Section 7: Buildings. Part II., which it is hoped will be completed in a few months' time, will cover the Wiring Symbols, *i.e.*, the symbols for the actual apparatus used with the electrical connections, and written circuits or simplified wiring diagrams.

These publications should prove of great interest and value to all railway staffs concerned, not only in operation but more particularly on the practical engineering side of railway working, and should be the means of saving much time in the preparation of plans.

BRASS TUBES AND SCREWED GLANDS FOR CONDENSERS.

The British Engineering Standards Association has recently published a specification dealing with brass tubes and screwed glands for condensers for land purposes upon similar lines to the specification issued in 1921 for tubes and glands for marine purposes. The present specification, however, provides for eight sizes of screwed glands, from ⅜in. to 1¼in. inclusive, and has, as in the case of the specification for marine purposes, clauses covering the quality of material, the dimensions of the tubes and the glands and mechanical and hydraulic tests.

COMPONENTS OF OPTICAL PROJECTION APPARATUS.

British standard dimensions for the components of optical projection apparatus have just been issued by the British Engineering Standards Association as British Standard Specification No. 379–1930.

These dimensions provide primarily for lanterns with slides 3¼in. by 3¼in., although the continental and American sizes of slide can be used with an appropriate carrier.

Two diameters of condenser lenses are recognised as standard, 4in. and 4¼in., and the diameters of the condenser mount and housing tube diameters are also specified. The height of the optical centre is specified, and where a lantern tray is used the width of the tray is also specified. The series of standard focal lengths of objective lenses, the diameter of the objective cylinder and jacket, and the height, thickness and face opening of the lantern slide carrier are also laid down. The dimensions of flanges for the lenses to secure interchangeability are given, and an appendix has been added giving the dimensions and tolerances for the inspection screw gauges suitable for controlling the manufacture of the screw threads. The specification was prepared by a representative committee set up at the request of the Optical Society.

Copies of these British Standard Specifications may be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria-street, London, S.W. 1, price 2s. 2d. each, post free.

THE INSTITUTION OF GAS ENGINEERS.

THE Institution of Gas Engineers is to hold a conference in Leeds from Monday, June 2nd, to Friday, June 6th next. The following programme has been arranged:—

On Monday, June 2nd, 1930, at 5.15 p.m., there will be a Council meeting at the Queen's Hotel. On the Tuesday, at 10.15 a.m., there is to be a reception by the Lord Mayor—Councillor N. G. Morrison, J.P.—at the Victoria Hall, Town Hall, which will be followed by the annual general

meeting and the delivery of the presidential address. Subsequently Professor J. W. Cobb will present a paper entitled "The Institution and the University: Teaching and Research." In the afternoon, at 2.30 p.m., a paper by Mr. C. F. Broadhead, of Melbourne, on "The Preparation of a New Road Binder," will be presented by Mr. Harold E. Bloor, in the Victoria Hall at the Town Hall.

On the Wednesday, at 10 a.m., the final extraordinary general meeting of the old Institution will be held at the Victoria Hall, Town Hall. Thereafter Dr. Margaret Fishenden, D.Sc., will read a paper on "Heat Transmission, with Particular Reference to Modern Methods of Expressing Convection Data," and Dr. E. W. Smith will read another on "Gas Dehydration." In the afternoon visits will be paid to the workshops of the Leeds Gas Department and to the Departments of Coal Gas and Fuel Industries and of Mining at the University of Leeds.

On the Thursday the annual general meeting of the Benevolent Fund will be held in the Victoria Hall, Town Hall, at 10 a.m. Afterwards Mr. Edward G. Stewart will read a paper on "The Functions of Coke Ovens," and Mr. Frank Prentice a paper on "Experiences with a Waterless Gasholder." In the afternoon, at 2.30, Mr. W. H. Hoffert and Mr. G. Claxton will present a paper on "Benzole Recovery, with Particular Reference to Gas-works Practice."

On the Friday, starting at 10.15 a.m., there is to be a motor tour in Wharfedale, arranged by and under the direction of Mr. Charles Wood, with luncheon at the Hotel Majestic, Harrogate.

The works of the Leeds Gas Department and of Clayton, Son and Co., Ltd., at Hunslet, and Wilsons and Mathiesons, Ltd., at Armley, may be inspected throughout the conference. The directors of the York Gas Company have invited members interested in the erection of a Klönne waterless gasholder to visit its works.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

General Situation.

THE iron, steel and engineering industries of the Midlands and Staffordshire continue to experience poor demand and, although here and there a slight increase in business is met with, the general situation is far from satisfactory. New business is urgently needed in most branches, and it will need to come forward early if the present rate of output is to be maintained. At the weekly meeting of the iron trade in Birmingham to-day—Thursday—conditions were dull, buying being of a restricted nature. Chief interest was displayed in the fight which has developed between producers and consumers of raw iron. No immediate development is expected, but the position is being closely followed by all sections of Midland industry. A revival of consumptive demand for iron and steel is much overdue and prospects, though slightly improved, are not yet considered to be good.

The Pig Iron Position.

Consumers of pig iron in the Midlands are openly antagonistic to the attitude of the blast-furnacemen in keeping prices up to recent levels despite the undisputed fall in costs of coke. They assert that it is their intention not to purchase a single ton more than is imperative to keep the foundries and forges in operation on definite orders. In face of the evidence of reduced pig iron consumption afforded by the diminished activity at the foundries and at the steel works and by the change which has recently come over the scrap market, it is difficult to believe that the position of furnacemen has not likewise deteriorated. Smelters are evidently relying on the belief that consumers will be forced to buy more largely in the near future as a result of the seasonal demand. Consumers of pig iron, for their part, are equally sure that furnacemen will be forced to grant price concessions before much longer. The position has developed into something in the nature of a siege, and it is an open question which side will be able to hold out the longer. At date, business in pig iron is decidedly slack. Derbyshire furnacemen feel it less than others, however, on account of the active conditions ruling in the pipe trade. This branch of foundry practice is absorbing a large proportion of the output of Derbyshire iron and smelters are, to a large extent, independent of the general market outlets. Northamptonshire furnacemen are not so fortunate, and rumours are current of considerable stocks of iron at their furnaces. So far there has been no weakness displayed by Midland smelters, and pig iron quotations are firmly held at the level fixed by the Producers' Association.

Furnace Coke.

There is now almost a glut of furnace coke, and while producers have made some attempt to fix a minimum at 15s. 6d. at the ovens, business can be done as low as 14s. 6d. and probably 14s., if an attractive order were in prospect.

Staffordshire Wrought Iron.

Makers of wrought iron in Staffordshire are unevenly employed. Mills producing marked bars are able to keep in continuous operation thanks to a steady flow of orders for this high-class engineering material. This, however, is the only really satisfactory section of the trade. In the Crown and common bar departments makers continue to complain of their inability to meet competition. The lowering of price of pig iron by 1s. per ton to forgemen is welcome, but the ratio of profit on present turnover of finished iron is too small materially to affect the situation. No concession in selling prices could possibly be made on account of this reduction in production costs. Ironmasters further remind their customers that the rate of wages payable to their employees has advanced since selling prices of wrought iron were stabilised at the present level. Forge and foundrymen in this district adhere to their policy of hand-to-mouth buying. Purchases are kept to the irreducible minimum. Only in the best bar department is there any reserve of orders. Crown bars sell very slowly, while the demand for Staffordshire nut and bolt and fencing bars is poor indeed. Consumers of finished iron who find competition keen, appear unprepared to pay the price for genuine wrought iron. They are purchasing either the steel equivalent or continental raw material. In the strip department, business, though better than at the end of March, is still unsettled. Mills are, for the most part, disposing of their output and see no reason to alter their quotation of £11 2s. 6d. per ton delivered. Other iron prices are unchanged, marked bars being £12 10s. at makers' works; Crown bars, £10 to £10 7s. 6d.; nut and bolt bars, £9 upwards delivered.

Steel.

Demand for finished steel on the Midland market is unsatisfactory and no improvement on recent weeks is discernible. Specifications for structural material are small, and it is difficult for mill owners to arrange rolling programmes. The situation in the plate and other departments is unaltered, but an early improvement of business is generally anticipated. Some of the consuming works are beginning to experience a slightly better demand for their goods, and stocks of steel at the manufacturing works are being reduced. Finished steel prices regulated by the Association are unchanged, as are quotations for other classes of heavy steel. In the semi-finished department there is little business accruing to either local steelmasters or their continental rivals. In an effort to persuade consumers to buy native material some sellers of billets have this week offered supplies at £6 per ton, a "cut" of half-a-crown on the quotation of the majority of English firms. Whether they have met with much success is difficult to determine. Rollers of small steel bars maintain their quotation, though there has been a definite lack of new business of late. Birmingham merchants dealing in foreign steel are also experiencing a dearth of orders. They quote steel strip at £6 16s. 6d. to £6 17s. 6d., a somewhat lower figure than that recently named. English strip is valued at £8 per ton. It is noticeable that Welsh mills, which are usually very keen to secure orders from this district, have not been seriously seeking business in Birmingham for the past week or so.

Sheets.

There is no change in the market situation so far as it concerns galvanised sheets. Demand continues poor on export account and moderate for home consumption. Millowners adhere to the agreed selling figures, 24-gauge galvanised corrugated sheets being £11 17s. 6d. per ton. Black sheets are in steady request at recent rates, but even in this department business is reported to be below normal for the time of the year. Little interest is displayed in this district at date in tin-plate.

Coventry Sewage Disposal.

An important stage in Coventry's new sewage disposal scheme was reached on Wednesday of last week, when the Deputy Mayor—Alderman F. Snape—opened a sluice at the Rock Farm, Baginton, and admitted the sludge from the sedimentation tanks, a mile or so distant, into the first of the primary digestion tanks which have been constructed. The scheme, which involves a total cost approaching a quarter of a million pounds, provides for two of these tanks, each of which, constructed in brick-lined mass concrete, is 51ft. by 62ft. and 16ft. 6in. deep to the top sludge level and has a capacity of 325,560 gallons. From the primary tanks the sludge will eventually be pumped into secondary tanks adjoining, there to complete the process of digestion, when it will be run by gravity on to the drying beds, which occupy an area of about 6 acres. An oil engine has been installed to pump back any drainage from the beds to the sedimentation tanks, so as to ensure that no drainage finds its way into the rivers Sowe and Avon. At Finham, where the eighteen bacteria beds included in the scheme are to be constructed, a mechanical digger has just begun excavating for the humus tanks.

From Birmingham to U.S.A.

Exports of goods through the Birmingham Consulate to the United States of America last quarter are regarded as fairly satisfactory. While increases are shown in some categories, there are decreases in others. The total value is recorded at 3,303,702 dollars, against 2,505,924 dollars, but as the area from which the trade is drawn has been enlarged, the figures are not really comparable. It is noticeable, however, that exports of brass manufactures increased in value from 28,439 dollars in the corresponding quarter of 1929 to 38,554 dollars, while machinery increased from 88,813 dollars to 94,461 dollars. Exports of steel tubing showed a decline, as did those of needles, pins, pens, steel sashes and metal manufactures.

Colonial Contracts.

Steelmasters, amongst other industrialists in the Midlands, welcome the news that the Metropolitan Cammell Carriage, Wagon and Finance Company, Ltd., of Saltley and Washwood Heath and Nottingham, has received from the Crown Agents for the Colonies orders for 200 four-wheeled all-steel covered goods wagons and for electrical equipment for saloon coaches for the Kenya and Uganda railways.

Cannock Chase Coal Profit.

There was a profit of 1s. 0·96d. per ton on all coal raised in the Cannock Chase and Pelsall coalfield during the month of March. The ascertainment of the proceeds of the industry for the three months January, February and March show the capacity of the owners to pay wages this month at the rate of 39·56 per cent. above the 1911 wage basis. The men will, however, under the agreement, receive the minimum of 42 per cent. above the basis. The accumulated deficit now due to the owners amounts to £1,172,312.

Warwickshire Miners' Wages.

The ascertainment of trading results in the Warwickshire coalfield reveals that the industry can only pay wages in May on the basis of 47 per cent., as against 48 per cent., the figure which ruled in April. The percentage reduction is so small, however, that little difference will be made in the wages payable to miners in this coalfield.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Industrial Outlook.

THE position of the Lancashire engineering trades is reviewed as follows by the Manchester Chamber of Commerce in the course of a survey of general industrial conditions in the area: Several engineering firms have secured good contracts lately, but a wide difference exists between some sections and others. Textile machinists have had a bad time, as there is nothing approaching full employment for existing machinery in the mills, and few firms have capital available for buying new. Even the rayon section has been unable to do much in that direction. Constructional engineers have had a good deal of work in hand, but new orders have not come in satisfactorily in some cases. Locomotive engineers are working on a number of overseas contracts, and on the whole are doing fairly well. Electrical engineers have continued to get a good deal of business, especially in the heavy branch, and machine tool makers also have been well engaged.

Additions to Order Books.

Several additions to order books of Lancashire and Cheshire engineering firms have been announced during the past week. Perhaps the most important is that secured by Beyer, Peacock and Co., Ltd., Gorton, Manchester, for twenty-five tank engines, this being a quarter of the large order just distributed by the Great Western Railway Company. The same firm, it will be recalled, a few months ago secured a locomotive order from the London, Midland and Scottish Railway Company to the value of about £300,000. Charles Walmsley and Co., manufacturers of paper-making machinery, Bury, has received a further large order for plant for shipment to Finland. A contract for transformers for New Plymouth, New Zealand, has been placed with the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. Williams and Williams, Ltd., Chester, has just secured an order for metal windows for the factory and and distributing depôt at Stockholm, which is under erection by the Ford Motor Company.

Withdrawn Tenders.

"Price rigging" was one of the allegations against contractors when the question of withdrawn tenders came under consideration by the Lancashire County Council. A proposal was eventually adopted providing for a new standing order which stipulates that a firm withdrawing a tender or declining to sign a contract when called upon to do so, or not carrying out a contract satisfactorily shall be debarred from tendering for a period of three years. It was stated in the course of the Council debate that seven instances of withdrawn tenders had come under notice during the past eleven months.

Hold-up of Dock Extension Schemes.

The delay in proceeding with the important development schemes on both the Liverpool and Birkenhead sides of the river Mersey was stated at a meeting of the Mersey Docks and Harbours Board to be due entirely to a hold-up for various reasons in Government Departments. Altogether, the work projected involves an outlay of about £2,000,000, and includes dock construction and extensions and the erection of several new bridges.

More Capital for Electrical Engineers.

To provide funds for extensions, the directors of Ferranti, Ltd., electrical and general engineers, Hollinwood, near Manchester, propose to increase the authorised capital of the company from the present amount of £300,000 to £900,000. Last year a dividend of 12 per cent., free of tax, was paid on the ordinary share capital, the net profit for the twelve months amounting to £66,976.

Sheet Mills to Close.

Owing to lack of orders, attributed largely to the fact that Japan now manufactures her own steel sheetings, the Marsh Mills of John Summers and Sons, Ltd., Shotton, near Chester, have been closed indefinitely, and about 2000 iron and steel workers are unemployed in consequence.

Non-ferrous Metals.

In spite of the recent very serious falls in prices in all sections of the non-ferrous metals markets, the experience during the past week has not been such as to inspire confidence, on the reasoning that after such declines a rise, or series of rises, is bound to follow in the future of values. Since my last report, the most serious fall, both actually and relatively, has been in tin, and it is interesting to reflect that the decline on balance for the week of about £14 per ton brings current quotations for the metal to nearly £30 below what they were no further back than late in March. In many instances users are taking advantage of the low rates, both in this section and in others, to cover their needs, but that the support thus accorded is not sufficient is obvious, and uncertainty as to the future is widespread. Electrolytic as well as standard brands of copper have continued under bearish influences, and in the latter further important losses of between £3 and £4 per ton, according to position, have to be recorded. Heavy available supplies of both spelter and lead, in combination with restricted buying interest, have exercised

a weakening effect. Spelter is cheaper by about £1, whilst the loss in lead is in the neighbourhood of 15s., bringing values in each section down to new "lows."

Iron and Steel.

Depression has been pretty general throughout the iron and steel markets this week, and sellers are not disposed at the moment to take a too cheerful view of prospects. For the most part the demand for pig iron has been on hand-to-mouth lines, and only in rare instances are users disposed to venture more than a few weeks ahead. Staffordshire and Derbyshire foundry iron is maintained at 77s. per ton, for delivery in the Manchester price zone, with Scottish brands at about 95s. per ton and West Coast hematite at 92s., both delivered. Bar iron is quiet, but steady at £10 15s. per ton for Lancashire Crown quality and 20s. less for No. 2. In the steel market this week there has been only a very moderate offtake of both general and boiler plates, although in respect of the latter there is hope of a rather better movement before long. The demand for constructional materials is described by most rollers here as unsatisfactory, and inquiry from textile machinists, boilermakers, and general engineers is on a relatively poor scale. Boiler plates are maintained at about £9 17s. 6d. per ton for acid and basic sorts, general plates at £8 17s. 6d., small re-rolled bars at from £8 to £8 2s. 6d., joists at £8 10s., sections at £8 7s. 6d., and 3in. and upward bars at £9 7s. 6d. Foreign materials, both finished and semi-finished kinds, meet with a very circumscribed market, and the basic price position is much less strong than the nominal maintenance of the continental cartel rates would appear to indicate. It is pretty certain that the latter are being "cut," though without much appreciable effect.

BARROW-IN-FURNESS.

Hematite.

The hematite pig iron market is unchanged. There has been a tendency on the part of buyers to get prices down, but in view of the fact that there is little, if any, margin on present prices, quotations remain firm. East Coast competition is a factor in the situation, but there are numerous customers, particularly those overseas, who have a preference for West Coast hematite. According to present signs, there is little chance of there being a reduction of output for some months to come. More pig iron is available for the open market at Barrow, owing to the steel departments being idle at present. There was a shipment of iron from Barrow last week for Philadelphia, and continental business continues. The demand for special iron of stated analysis is maintained. Iron ore is about the same. The steel trade is moderate. Workington is engaged on rails for South America. Since all the steel orders placed with the United Steel Company are executed at Workington, the mills have been busier. Barrow is still idle, and there is no statement available as yet as to the restarting.

SHEFFIELD.

(From our own Correspondent.)

No Sign of Recovery.

THE spell of extremely bad trade which has fallen on many centres of the metal industry, both in this country and abroad, is seriously affecting Sheffield and district. So far as the general demand for steel is concerned, the local works are suffering from depression to a considerable extent. There is now less work on hand, or being booked, than there was before the Easter suspension, and signs of improvement are altogether absent. The difficulties of export trade are excessive. Australia is buying little or nothing, while the disturbances in India are affecting business adversely in many departments. In South America keen German competition and other influences are restricting the demand for British goods. In the open-hearth steel department production remains on the same scale as before, but makers have few forward bookings on hand, and a serious feature of the situation is the absence of bulk inquiries. The railway steel departments are only moderately employed. Most of the orders for railway rolling stock in India are being placed on the Continent. In the sections devoted to special steel products and tools there is steady business, but no pressure.

Lincolnshire Following Suit.

The bright spot in the local trade situation, for a considerable time, has been the great activity in North Lincolnshire, the mild steel works of which have been able to keep going to the full extent, but even there the shine has now begun to wear off. A considerable shrinkage in new bookings is reported from that centre, and a striking instance of the changed order of things has just been afforded by a decision of the Frodingham Iron and Steel Company to close down its melting shop at Frodingham. Orders have fallen off to such an extent that it can make all the ingots it at present requires at the new works at Appleby, and operations are to be concentrated there until further notice. At Frodingham work will continue in both the 14in. and the 30in. mills, because of the large stock of ingot steel now being carried.

Finished Steel Products.

There is severe competition in various classes of tools, both among the home manufacturers themselves and from foreign sources. Garden tools have had a poor season so far, and trade does not expand as the year progresses. There is a fair demand for twist drills and milling cutters. The saw and file departments are short of work. Some amount of work is on hand for Russia, but there are no large orders from that once extensive market.

Washington Hours Convention.

There is much uneasiness in the crucible steel trade at the prospect of the Government ratifying the Washington (Hours) Convention. The Crucible Steel Makers' Association states that a literal ratification would shut down 50 per cent. of the melting holes, and the Hours of Industrial Employment Bill is being carefully watched. It is contended that an eight-hour day in the trade would seriously send up the costs of production. For economic working three continuous heats or rounds per day are necessary. The value of this system is that the heat created in the first and second rounds is almost sufficient for the third also, so that for this last operation little or no additional fuel is required.

Production of Foundry Sands.

An enterprise of great interest to the foundry trade was initiated last week at the South Cave sand quarries, near Hull. Two local firms—Yorkshire Amalgamated Products, Ltd., of Doncaster, and General Refractories, Ltd., of Sheffield—have jointly installed an up-to-date milling, grinding and disintegrating plant, by means of which they propose to produce sand ready mixed to suit the varying requirements of the foundry industry. Over an area of 30 acres, with a face 40ft. deep, the quarries possess great deposits of red bonding sand and yellow silica sand. Neither of these, singly, is suitable for its purpose, but they have been sold to iron and steel founders in Sheffield, Manchester and elsewhere, who have mixed them to the proportions they needed. Now the joint companies will mix the sands themselves, under technological supervision. It is contended that they will be more regular and reliable than what are known as the natural bonding sands of the Continent, which, though found in a state almost ready for use, are less reliable by reason of their variability, and it is hoped that the enterprise will therefore have the effect of meeting foreign competition. The milling machinery has been supplied by the Brightside Foundry and Engineering Company, Ltd., and is driven by a Robey oil engine.

Industrial Developments.

The circular saw and file departments of Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield, are being entirely reconstructed and new plant and machinery of the most modern type is being put down. The reconstructed by-product coking plant of John Brown and Co., Ltd., at Canklow, has been started up. It consists of 28 ovens, with a carbonising capacity of approximately 3000 tons per week. The effect of modernisation is seen in the fact that the number of men employed will be about 50, whereas there were 120 on the old plant, although its capacity was only 2000 tons per week. The Staveley Coal and Iron Company is about to take up the manufacture of sand-spun iron pipes, the British rights of which, under an American patent, it has secured. It is said that greatly improved pipes can be produced by this process. In order to carry it out, the company is erecting an entirely new factory near its general offices at Barrow Hill, and it hopes to be in a position to produce the pipes soon after Christmas. The extensions at the Staveley Works have necessitated the demolition of the Dowell open-air swimming bath. Another is to be built in Ringwood Park. The preparation and excavation of the site will be done by members of the works swimming club themselves, in their own time, and the company has promised to put in a new and improved bath.

Trams and Buses.

Sheffield Tramways Committee recommends that the tender of Leyland Motors, Ltd., of Leyland, Lancashire, for 15 double-deck motor omnibuses be accepted, subject to the company purchasing from the department 12 A.E.C. double-deck motor omnibuses, which are to be replaced by the new vehicles. Some surprise has been expressed in Sheffield at the fact that the same Committee recently gave orders for 800 tons of rails, a large number of fish-plates and other material, of a total value of about £10,000, to the Cargo Fleet Iron Company, Ltd., of Middlesbrough. The cost of transporting the material from Middlesbrough to Sheffield is something like 15s. per ton. In the past, the Sheffield Corporation has obtained its rails from Steel, Peech and Tozer, Ltd., of Rotherham, hence the surprise that the recent work has been given to the North-East Coast. It appears, however, that Steel, Peech and Tozer did not send in a tender, because it had been decided to close down their rail mill. That plant is still idle, but that of Samuel Fox and Co., at Stocksbridge, which is included in the same industrial group, is running.

Bridge Work.

The tender of the Yorkshire Hennebique Contracting Company, Ltd., of Leeds, for the widening of the Severn Bridge at Worcester, has been recommended to the Worcester City Council for acceptance, subject to the Ministry of Transport confirming an offer to contribute 75 per cent. of the outlay. The tender amounts to £44,644. The East and West Riding County Councils have held a conference on the subject of building a new bridge over the Ouse at Selby. They recommend the erection of a bridge at or near the site of the existing toll bridge, subject to the Ministry of Transport granting 75 per cent. of the cost of the new work and also bearing the cost of acquiring the toll bridge. The estimated cost of the new structure itself is £87,000.

Scissorsmaking by German Methods.

An announcement that Mr. P. C. Hoffman, one of the city's Members of Parliament, proposed to ask several questions in the House with regard to the employment of three Germans by a Sheffield scissors firm, has brought forth an interesting statement from Mr. P. B. Colver, managing director of George Wostenholm and Son, Ltd., cutlery manufacturers, of Sheffield. Mr. Colver states that the firm is installing a very complete plant for the manufacture of scissors by German methods, which it considers to be superior to the methods in use in Sheffield. It has spent some thousands of pounds upon the plant, and has engaged two Germans, who are thoroughly acquainted with its operation and who will train Sheffield workpeople in the use of the new machines. It obtained permission from the Home Office for the Germans to come over. A third German came over with regard to a nickel-plating plant. He was sent by the manufacturer by whom he was employed. He was in Sheffield for a short time, and has now gone back. "So far from depriving Sheffield workpeople of work," adds Mr. Colver, "we hope to employ considerably more when we get our new plant going."

NORTH OF ENGLAND.

(From our own Correspondent.)

Iron and Steel Trade Decline.

A MARKED contraction in the business passing in the iron and steel trade in the North of England is causing much anxiety. The outlook is distinctly ominous. Production is rapidly declining, stocks at makers' yards are heavy, and, synchronising with the decline in the export trade, there is a steady increase in the imports of material from abroad. When the Cleveland ironmasters cut prices by 5s. per ton, it was anticipated that an expansion in the export trade would be their immediate reward. Instead, the foreign trade has actually declined, and there has been a similar contraction in the deliveries to Scotland, where foreign iron is a formidable competitor. The exports of iron and steel from the Cleveland district during April totalled only 60,313 tons, as compared with 80,991 tons in March. The pig iron shipments dropped from 20,208 tons in March to 14,345 tons in April, and manufactured iron and steel exports from 60,783 tons to 45,968 tons. To Scotland only 4604 tons of pig iron were shipped, compared with 8713 tons in March, and only Italy took a bigger quantity in April than in the preceding month. In the steel section it is noteworthy that whereas over 12,000 tons were shipped to South America in March, not a ton was so shipped in April.

Iron and Steel Imports.

A return of the iron and steel imported into the river Tees for the six months ending April, shows that during that period 77,460 tons were brought in, compared with 92,253 tons in 1928–29, and 37,700 tons in the pre-war period of 1913-14. Crude sheet bars, billets, blooms, slabs, &c., imported, reached 55,125 tons, as against 50,347 tons and 24,134 tons respectively. The imports of plates, bars, angles, rails, &c., totalled 16,648 tons, as compared with 23,987 tons and 13,460 tons, while 5687 tons of pig iron were unloaded, as against 17,919 tons and 106 tons respectively.

Cleveland Iron Trade.

There is still only the faintest sign of life in the Cleveland iron trade. There have been better shipments from the Tees this week, and on the whole the limited output of iron is fairly well taken up. It is, however, very difficult to regain a footing in markets abroad, and sales to Scotland are very limited. However, prices are still quite firm, with 67s. 6d. as the ruling figure for the standard No. 3 quality. No. 1 Cleveland foundry iron is 70s., No. 4 foundry 66s. 6d., and No. 4 forge 66s.

Hematite Pig Iron.

East Coast hematite pig iron production is excessive, notwithstanding the reduced make caused by two furnaces going out of action. Export sales are few and small, and home demand is much below what was looked for early in the year. Quotations are irregular. Ordinary qualities are offered freely at 74s., and customers claim that they experience no difficulty in satisfying their requirements at less.

Ironmaking Materials.

The foreign ore trade is still idle. Nominally, best Rubio ore remains at 21s. c.i.f. Tees. Users of blast-furnace coke are not disposed to negotiate for forward supplies. Sellers offer good medium kinds freely at 18s. delivered to works in this area.

Manufactured Iron and Steel.

Keener competition from continental sources is being experienced in the manufactured iron and steel trade. New business matures very slowly, and unless an early expansion of demand occurs, manufacturers will be compelled to lay plant idle. Quotations are upheld.

The Coal Trade.

The Northern coal trade shows little, if any, improvement. The demand is exceedingly quiet, but there is a prospect of the pits working more regularly than has been the case for two or three weeks past. Durham is more favourably situated in this connection than Northumberland, there having been a little more trade for coking coal. Northumberland steam coals are in ample supply, and it is not easy to make clearances. The direct sellers hold to the fixed minimum of 13s. 6d., but concessions are obtainable through second hands. The outlook for small coal is good, and prices are well held, but the volume of output is much below the normal average. Tyne primes are now available at the minimum of 12s. 9d., and ordinary kinds are on offer at 10s. 6d. In the Durham section, gas fuel has entered upon the dull season, and trade is slow. In these quiet times coking coal is doing as well as any class, and producers of the best kinds can still obtain the full late prices. A fair number of vessels, which have been laid up on the North-East Coast, are beginning to move off to the Russian timber trade, and their departure will help the bunker coal trade. Best qualities are already tending to become a little firmer. The demand for gas coke is active, and, with production very much below normal, holders can command a firm price of 21s. for export in any direction. Patent oven coke is idle. The proposed cartel arrangements for the Scandinavian countries are severely limiting business, and for other centres buyers hold off under the belief that the high prices asked for shipments to the Baltic areas will severely limit the demand, thus causing more stocks to be offered at easier values for other continental centres. Patent oven coke for open ports shipment remains at a nominal 18s.

Coal Trade Wages.

The latest ascertainments concerning the coal trade in Northumberland and Durham indicate a falling off in trade and prices. In Northumberland the miners have lost a small advance in wages which they received in April, and the economic yield in Durham is still very considerably below the minimum percentage on basis wages. The proceeds and costs in Northumberland in March, which would regulate wages in May but for the minimum under the county agreement, shows that wages would be 39·67 per cent. on the basis. This compared with 43·66 per cent. in February, is a fall of 3·99 per cent. The minimum is 40 per cent. on the basis, therefore the deficiency to be made up by the owners is ·33 per cent. The surplus of 3·66 per cent. last month was divided between the miners and owners, and therefore the men lose their proportion of 1·83 per cent. in the present month, as the economic yield of the coal is not sufficient to pay the minimum percentage of 40. In Durham the March proceeds show that the wages this month would be 51·18 per cent. on the basis, as against 60·03 per cent. in April, a drop of 8·85 per cent. The minimum is 65 per cent., and thus the owners have to make up a deficiency of 13·82 per cent. in terms of the county agreement.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

THE outlook in the shipbuilding industry, so far as the Clyde yards are concerned, is comparatively dull at present. There are very few inquiries for new tonnage, and orders placed during April were practically nil. It is hoped that one of the large yards will receive the contract for the new Cunarder. Speaking generally, there are far more unoccupied than occupied berths, and there seems little likelihood of an early improvement in this respect. The tonnage launched during April amounted to nineteen vessels of 31,628 tons aggregate, which is the lowest figure for this year to date. The total for the four months, amounting to sixty-two vessels of 147,199 tons aggregate, is about 40,000 tons less than in the same period last year. The vessels launched during April included the following:—"Storanger," twin-screw motor tanker, 9400 tons, built for Westfal, Larsen and Co., Bergen; "Atheltemplar," twin-screw motor tanker, 8940 tons, for the United Molasses Company, Ltd., London; and the "Dalfram," cargo steamer, 4650 tons, for the United Steam Navigation Company, Ltd., Newcastle-on-Tyne.

Steel.

Business on the whole is dull, due in a measure to the falling off in orders for shipbuilding materials, and also to a very poor export demand. Employment is irregular and several works have been forced to resort to short time. Black sheets are fairly busy, but meet considerable competition from light mills. Galvanised descriptions are only moderately busy. A slight improvement is reported in the tube trade. Small butt-welded and lap-welded tubes are poorly specified, however, and a three-days' working week is the usual period.

Iron.

Bar iron makers and steel re-rollers are very short of orders, and here, again, short time is prevalent. Prices of the former are unchanged, and the latter are still round about £7 12s. 6d. per ton, home and export.

Pig Iron.

The market for pig iron is comparatively dull. The meagre output is ample to meet all demands, and a very quiet business is being done at minimum quotations.

Locomotives.

The North British Locomotive Company has received an order from the Great Western Railway for twenty-five side tank 0–6–0 class locomotives.

Scrap.

The market for scrap is comparatively quiet, and prices as a rule remain easy, round about 69s. 3d. for cast iron machinery, 65s. heavy steel, and 62s. 6d. per ton heavy basic.

Coal.

A seasonal decline in demands for home consumption causes further depression in the coal trade, and considerable short time is now being experienced in the West of Scotland, as well as in the Lothians and Fifeshire, where the collieries are heavily hit by the scarcity of export business. Practically without exception all descriptions of fuel are in need of business, and the market is weak all round. Aggregate shipments amounted to 258,460 tons, against 248,992 tons in the preceding week and 285,785 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

SHIPMENTS from this district last week marked an improvement on those of the preceding week, but still the conditions prevailing in the industry continue to be very unsatisfactory. May Day was celebrated in different areas in South Wales at varying times, ranging from Thursday in last week up to Monday of this week, and the proceedings passed off without anything untoward happening. Inasmuch as the existing stocks of coal all round are so heavy there could be little complaint about the suspension of work in the coalfield for the purpose of celebrating May Day; it is more possible that in a number of directions it was welcomed by coalowners. It is safe to say that very few undertakings have been ready or able to work regularly, owing to the accumulation of stocks and the lack of a ready outlet for their production. At the end of last week there were twenty-nine idle tipping appliances at the various docks, and the present week was started with the conditions in this respect very little better, as on Monday there were twenty-two appliances idle. New business to come along is negligible; the threatened strike of miners in the Asturian coalfield, as from the beginning of this month, did not take place, so that a number of inquiries which were being received from Spain in anticipation of a stoppage of work there have not matured. Still there is a hope of operations expanding to some extent, for the reason that outward freights have taken a decided turn for the better, and that may induce foreign buyers to come along more promptly perhaps. The continued laying up of tonnage is now really being felt. There are over 800 vessels, with a carrying capacity of over 4,500,000 tons, out of commission. A good number of steamers are now off this trade and have gone up the Baltic, and there is no question that for most directions there is a stiffening of outward rates and merchants are experiencing difficulty in securing the space they require, even by paying 3d. to 6d. per ton more than was offered a week ago.

Coal Mines Bill.

Since writing a week ago there have been several important statements concerning the inimical effects of the new Mines Bill upon the South Wales coal industry. They have come from Mr. D. Farr Davies, the Chairman of the Monmouthshire Coalowners Association; Mr. G. D. Budge, the President of the South Wales Institute of Engineers; while the Independent South Wales Coalowners' Committee has addressed a statement to the House of Lords. It is contended that South Wales will suffer more than any other area under the new legislation, for the reason that 60 per cent. of the coals produced are exported. The effect of a 7½-hour day would be to increase the cost of production by 1s. 6d. per ton, but a spread-over of hours in the shape of 45 hours per week, or 90 per fortnight, would go far to relieve the industry from this extra burden, and would reduce this increased cost to 6d. per ton. The district levy is described as useless and incapable of application in this district, where the proportion of export trade is 60 per cent. It means that the 20 million tons of coal for the inland trade would be levied at about 3s. 9d. per ton to subsidise the export trade of 30 million tons at 1s. 6d. per ton to make good the shortening of hours. Mr. G. D. Budge put this point in another way, and estimated that the extra cost of the shorter day would have to be borne by 40 tons out of every 100 tons produced, and on that 40 tons the coalowners would have to obtain 150s. extra to run the industry under the new Government measure. It is, of course, difficult to see how any extra price can be saddled on inland consumers in this district when the tin-plate trade, the galvanised sheet and iron and steel industries are by no means doing well under existing conditions. There was a special meeting of the Welsh Coal Conciliation Board at Cardiff on Tuesday, when an effort was made by the coalowners' representatives to come to an arrangement with the miners' representatives regarding the question of working hours in South Wales. They appealed to the men's leaders to agree to the principle of a 45-hour week or 90-hour fortnight, but the men's leaders replied that they were bound by the policy of the national organisation. No agreement was therefore come to.

Coal-trimming Hours.

There was a conference at Cardiff on Friday last relative to the proposal of the coal trimmers and tippers for the abolition of night work at South Wales ports and for a reversion to the system of two continuous shifts. Both the coal exporters' and shipbrokers' organisations had expressed their disapproval of any such change, and when the conference met the suggestion of the men's representatives was entirely rejected. The men's leaders thereupon decided to leave the matter to the workmen, who are now balloting on the matter, and a report of the returns will be submitted to the men's leaders at a meeting to be held at Cardiff on the 14th inst.

Proposed New Entrance Lock at Swansea.

A recent special general meeting of the Great Western Railway Company approved the Bill deposited by the company for the purpose of carrying out new works at Port Talbot and Swansea, but some surprise was later occasioned by the announcement of the secretary of the South Wales Coalowners' Association that that organisation must petition against the Bill, in view of the provisions of Clause 7. The Association does not oppose the proposal of the company to build a new lock, but feels that it must protect its position regarding the charges to be imposed at the port. Since then the Swansea Chamber of Commerce has passed a resolution strongly supporting the Bill, and at its meeting, the President, Mr. Ivor Ambrose, stated that it had received a message from the secretary of the Coalowners' Association that, in the event of Clause 7 being agreed to, the railway company would have power to impose any charges it desired at Swansea without reference to any tribunal. The company, however, had given the Coalowners' Association an assurance that if it persisted with its petition the clause to which the coalowners objected would be withdrawn during the Committee stage.

Coalfield Items.

The dispute which was the cause of a stoppage of work for a week at the Bargoed Steam Coal Colliery and affected about 1000 men has been settled. This dispute concerned eight men engaged on a conveyor face. They have now been reinstated. The trouble at the Crumlin Valley Colliery has also been averted. Here, again, the question affected the reinstatement of workmen, over which about 1000 men came out on strike.

Swansea Docks Bill.

With regard to the Great Western Railway Company's Bill for new works at Port Talbot and Swansea, including the construction of a lock entrance at Swansea, it is now announced that the South Wales Coalowners' Association has withdrawn its opposition. The Bill has now been referred to the Committee charged with the consideration of unopposed measures.

Current Business.

Coal market conditions continue to be featureless. There is extremely little new demand, and shipments are for the most part on old contracts. Prices of all grades are on the minimum, and buyers can easily satisfy their requirements, owing to standing stocks being so heavy. Coalowners have made a reduction of 1s. 6d. per ton in the pithead price of best Welsh house coal, as from the 1st inst., thus bringing the price to 25s. per ton at pit. Coke and patent fuel remain without any change. Pitwood is a shade steadier at 26s. 6d. to 27s.

CONTRACTS.

THE CONSTRUCTIONAL ENGINEERING COMPANY, Ltd., of Birmingham, has recently received orders for a total of eleven cupolas, &c., of different sizes, from customers in South Africa, Birmingham, Liverpool, Yorkshire, India, the Midlands and the South of England.

THE PREMIER RADIATOR AND ENGINEERING COMPANY, Ltd., of Darlington, has received orders for the water-cooled transformer oil coolers for the new Battersea Power Station, and also has in hand coolers of the air-blast type for the S.E. Central and N.W. England sections of the "grid."

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE ATLAS STONE COMPANY, Ltd., of General Buildings, Aldwych, London, W.C., asks us to announce that it has opened a new factory in Cambridgeshire for the manufacture of cement asbestos flat and corrugated sheeting, slates, tiles, &c.

THE GENERAL ELECTRIC COMPANY, Ltd., asks us to announce that its Adelaide branch of the British General Electric Company, Ltd., Australia, has been moved from "Magnet" House, 21, Pulteney-street, to Industrial Building, King William-street, Adelaide.

SIR W. G. ARMSTRONG WHITWORTH AND CO. (IRONFOUNDERS), Ltd., of Scotswood Works, Newcastle-upon-Tyne, has been formed for the purpose of taking over and operating the business of ironfounders and manufacturers of refined pig iron formerly carried on by Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd. The capital of the company is £130,000, the whole of which is owned by the parent company—Armstrong Whitworth Securities Company, Ltd.

LAUNCHES AND TRIAL TRIPS.

CEFALU, steamship; built by Workman Clark (1928), Ltd., to the order of Vaccaro Bros.; dimensions, 397ft., 53ft. 3in., 33ft. 3in. Engines, quadruple-expansion; constructed by the builders; trial trip, April 23rd.

NORDBORG, steamship; built by Wm. Gray and Co., Ltd., to the order of Akt. Dampskibsselskabot Danneborg; dimensions, 290ft. 4in., 40ft., 21ft. 4in. Engines, triple-expansion, 20in., 31½in. 53in. dia. by 36in. stroke; pressure, 180 lb. per square inch; constructed by Central Marine Engine Works; trial trip, April 25th.

PRESTATYN ROSE, steamship; built by David and William Henderson and Co., Ltd., to the order of Richard Hughes and Co., Ltd.; dimensions, 220ft., 34ft., 16ft. 3in. Engines, triple-expansion, 17in., 27in., 45in. dia. by 33in. stroke; pressure, 180 lb.; constructed by the builders; launch, April 28th.

THE DURHAM BURSARY.—The Junior Institution of Engineers announces that the Durham Bursary, founded in 1908, of the annual cash value of £25, competition for which has hitherto been confined to members of the Institution, has recently been thrown open for competition to all young men between the ages of twenty and twenty-two years of British parentage who are in course of training for the engineering or an allied profession by employment in a technical office or works or by attendance at a recognised institute, college or university or in some other manner approved by the Council of the Institution. Competition for the Bursary is by the submission of a thesis on some engineering, technical or scientific subject selected by the candidate. The final date in any year for the receipt of theses is August 1st. Detailed conditions and entry forms may be had on application to the Secretary of the Institution at 39, Victoria-street, S.W. 1.

ELECTRIC TRANSFORMER TANK.—We are informed by G. A. Harvey and Co. (London), Ltd., that they have just completed one of the largest electrical transformer tanks ever produced. It is for the South-East England "grid" scheme, and is the first of a number on hand. The transformer is for 15,000 kVO, 132,000 volts, 50 cycles, three-phase. The tank is fitted with "Harco" gilled tubes of mild steel. In these tubes the inner edge of the gills is crimped during the operation of fixing, with the result that the surface of contact with the tube is increased as well as the radiation area. It is estimated that one of the tubes dissipates as much heat as three plain tubes, thus trebling the natural cooling possible, for, of course, there is a limit to the number of tubes which can be accommodated on a tank. The batteries of gilled tubes can be detached without emptying the oil from the tank, owing to the fact that special valves are provided, which, when closed, isolate the radiator from the tank, when it can be drained of oil and removed. The chief object in having these radiators detachable, however, is to make transport from the works to the site possible by their removal.

INTERNATIONAL CONGRESS OF CONSULTING ENGINEERS.—The fifth International Congress of Consulting Engineers is, by the invitation of the Austrian Association of Consulting Engineers, to be held this year at Vienna from September 4th to 7th. The Congress will be held under the auspices of the Fédération Internationale des Ingénieurs-Conseils, the offices of which are at 29, Rue René Dubrencq, Brussels, and to which are affiliated the following:—(*a*) The Verband Beratender Ingenieure Oesterreichs, Vienna; (*b*) the Chambre des Ingénieurs-Conseils et Experts de Belgique, Brussels; (*c*) the Foreningen af Raadgivende Ingeniorer, Copenhagen; (*d*) the Chambre des Ingénieurs-Conseils et Ingénieurs-Experts de France, Paris; (*e*) the Orde Van Nederlandsche Raadgevende Ingenieurs, Amsterdam; (*f*) the Tekniske Konsulenters Forening, Oslo; (*g*) the Kolo Inzynierow-Doradcow i Inzynierow Rzeczoznawcow, Warsaw; (*h*) the Svenska Konsulterande Ingenierers Förening, Stockholm; (*i*) the Schweiz Verband Beratender Ingenieure (Association Suisse des Ingénieurs-Conseils), Lausanne; and (*j*) the Sbor Civilnich Inzenyru-Poradcu v Ceskoslovensku, Prague. Particulars of the subjects to be discussed may be obtained on application to the Federation International des Ingénieurs-Conseils at the address given above.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	19/6 to 21/–
(1) Spanish	21/6 to 23/–
N.E. COAST—	
Native	18/– to 21/–
Foreign (c.i.f.)	21/–

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	4 1 0	—
No. 1 Foundry	4 0 6	—
No. 3 Foundry	3 18 0	—
N.E. COAST—		
Hematite Mixed Nos.	3 14 0	3 14 0
No. 1	3 14 6	3 14 6
Cleveland—		
No. 1	3 10 0	3 10 0
Silicious Iron	3 10 0	3 10 0
No. 3 G.M.B.	3 7 6	3 7 6
No. 4 Foundry	3 6 6	3 6 6
No. 4 Forge	3 6 0	3 6 0
Mottled	3 5 6	3 5 6
White	3 5 6	3 5 6
MIDLANDS—		
(3) Staffs.—	(*Delivered to Station.*)	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 15 6	—
„ „ Foundry	3 19 6	—
(3) Northampton		
Foundry No. 3	3 15 0	—
Forge	3 11 0	—
(1) Derbyshire—		
No. 3 Foundry	3 18 6	—
Forge	3 14 6	—
(3) Lincolnshire—		
No. 3 Foundry	3 13 6	—
No. 4 Forge	3 9 6	—
Basic	—	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 8 6 (a) / 4 10 6 (b) / 4 14 0 (c)	— / — / —

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 10 0	—
Common Bars	10 15 0	—
Best Bars	11 5 0	—
Double Best Bars	11 15 0	—
Treble Best Bars	12 5 0	—
LANCS.—		
Crown Bars	10 15 0	—
Second Quality Bars	9 15 0	—
Hoops	13 0 0	—
S. YORKS.—		
Crown Bars	11 0 0	—
Best Bars	11 10 0	—
Hoops	12 0 0	—
MIDLANDS—		
Crown Bars	10 0 0 to 10 7 6	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	9 0 0 to 9 7 6	—
Gas Tube Strip	11 2 6	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates (Marine)	10 10 0	10 10 0
„ „ (Land)	10 0 0	10 0 0
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	9 0 0	8 15 0
Sheets (Gal. Cor. 24 B.G.)	12 15 0	12 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 10 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	8 2 6	—
Soft Billets	6 17 6	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 10 0	—
Light Rails	8 15 0 to 9 0 0	—
Billets	6 15 0 to 9 10 0	—
MANCHESTER—		
Bars (Round)	9 7 6	—
„ (Small Round)	8 0 0 to 8 2 6	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	9 17 6	—
SHEFFIELD—		
Siemens Acid Billets	9 10 0 (basis)	—
Hard Basic	9 2 6 and 9 12 6	—
Intermediate Basic	7 12 6 and 8 2 6	—
Soft Basic	6 10 0	—
Hoops	9 15 0 to 10 0 0	—
Soft Wire Rods	8 0 0	—
MIDLANDS—		
Small Rolled Bars	8 0 0 to 8 15 0	—
Billets and Sheet Bars	6 0 0 to 6 12 6	—
Galv. Sheets, f.o.b. L'pool	11 17 6	—
Sheets (30 W.G.)	16 7 6	—
Angles	8 7 6	—
Joists	8 10 0	—
Tees	9 7 6	—
Bridge and Tank Plates	8 17 6	—
Boiler Plates	9 12 6	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18/3 to 18/6
Block Tin (cash)	142 7 6
„ (three months)	144 5 0
Copper (cash)	48 10 0
„ (three months)	48 7 6
Spanish Lead (cash)	17 1 3
„ „ (three months)	17 5 0
Spelter (cash)	16 0 0
„ (three months)	16 12 6
MANCHESTER—	
Copper, Best Selected Ingots	58 0 0
„ Electrolytic	60 0 0
„ Strong Sheets	92 0 0
„ Tubes (Basis Price), lb.	0 1 0½
Brass Tubes (Basis Price), lb.	0 0 11½
„ Condenser, lb.	0 1 1½
Lead, English	19 0 0
„ Foreign	17 12 6
Spelter	17 0 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/1 per lb.	
Ferro Tungsten	2/10 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 12 6	7/–
„ „ 6 p.c. to 8 p.c.	£22 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£22 0 0	7/–
„ „ Specially refined		
„ „ Max. 2 p.c. carbon	£33 10 0	10/–
„ „ „ 1 p.c. carbon	£38 0 0	13/6
„ „ „ 0·70 p.c. carbon	£40 0 0	15/–
„ „ „ carbon free	11d. per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£11 15 0 for home	
„ „ „	£11 0 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£11 10 0 scale 5/– per unit	
„ „ 75 p.c.	£19 0 0 scale 7/– per unit	
„ Vanadium	12/9 per lb.	
„ Molybdenum	4/2 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£170 to £175	
Ferro Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	12/6
„ „ Ell	14/–
„ „ Splint	16/– to 16/9
„ „ Trebles	12/–
„ „ Doubles	11/3
„ „ Singles	10/9
AYRSHIRE—	
(f.o.b. Porte)—Steam	13/3
„ „ Jewel	17/–
„ „ Trebles	12/6
FIFESHIRE—	
f.o.b. Methil or Burntisland—Steam	10/3 to 12/9
Screened Navigation	16/6
Trebles	12/– to 12/6
Doubles	11/–
Singles	10/9
LOTHIANS—	
(f.o.b. Leith)—Best Steam	12/3
Secondary Steam	12/–
Trebles	11/–
Doubles	10/9
Singles	10/9

ENGLAND.

(8) N.W. COAST—	
Steams	21/6 to 23/–
Household	38/– to 51/–
Coke	22/– to 22/6
NORTHUMBERLAND—	
Best Steams	13/6
Second Steams	12/–
Steam Smalls	10/– to 10/6
Unscreened	13/–
Household	25/– to 37/–
DURHAM—	
Best Gas	15/9 to 16/–
Second	13/3 to 13/6
Household	25/– to 37/–
Foundry Coke	26/– to 29/–

SHEFFIELD—	Inland.	
Best Hand-picked Branch	25/– to 26/6	—
Derbyshire Best Bright House	20/– to 22/–	—
Best House Coal	19/– to 20/–	—
Screened House Coal	17/– to 19/–	—
„ „ Nuts	15/– to 17/–	—
Yorkshire Hards	14/6 to 16/–	—
Derbyshire Hards	14/6 to 16/–	—
Rough Slacks	8/6 to 9/–	—
Nutty Slacks	7/– to 8/–	—
Smalls	3/– to 5/–	—

Blast-furnace Coke (Inland) 17/– on rail at ovens
Furnace and Foundry Coke (Export), f.o.b. 19/6 to 20/–

(9) SOUTH WALES.

CARDIFF—	Export.
Steam Coals :	
Best Smokeless Large	20/–
Second Smokeless Large	18/9 to 19/9
Best Dry Large	18/6 to 18/9
Ordinary Dry Large	17/6 to 18/–
Best Black Vein Large	18/3 to 18/6
Western Valley Large	18/– to 18/3
Best Eastern Valley Large	17/9 to 18/–
Ordinary Eastern Valley Large	17/6 to 17/9
Best Steam Smalls	13/3 to 13/9
Ordinary Smalls	12/6 to 13/–
Washed Nuts	17/– to 21/–
No. 3 Rhondda Large	20/6 to 21/–
„ „ Smalls	15/6 to 16/–
No. 2 „ Large	17/– to 17/3
„ „ Through	16/– to 16/6
„ „ Smalls	14/– to 14/3
Foundry Coke (Export)	30/– to 37/–
Furnace Coke (Export)	25/– to 27/6
Patent Fuel	22/– to 22/6
Pitwood (ex ship)	26/6 to 27/–
SWANSEA—	
Anthracite Coals :	
Best Big Vein Large	35/– to 37/6
Seconds	28/– to 32/–
Red Vein	23/6 to 27/6
Machine-made Cobbles	41/6 to 45/–
Nuts	40/– to 46/–
Beans	24/6 to 27/6
Peas	19/6 to 20/6
Breaker Duff	10/– to 10/6
Rubbly Culm	10/9 to 12/–
Steam Coals :	
Large	19/6 to 20/6
Seconds	18/– to 19/6
Smalls	12/6 to 13/6
Cargo Through	15/6 to 16/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate : Joists (minimum), 12/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 10/– if home consumers confine purchases from associated British Steel Makers.

French Engineering Notes.

(From our Correspondent in Paris.)

Trade Slackness.

ALTHOUGH the metallurgical and engineering trades are favoured by active building and public works undertakings, as well as by extensive railway orders, the situation is still becoming less satisfactory every week. It is certainly affected by the contraction of foreign trade and the depression abroad, and that is seen in the weakening prices of iron and steel which are causing particular uneasiness because they seem to confirm rumours that have been prevalent of late to the effect that the international sales comptoirs are powerless to keep prices from falling below the minimum level. If that be the case, the outlook is disquieting. The Steel Cartel and the comptoirs are now given an opportunity to show how far they can control the trade. Meanwhile, there is some surprise at the notable increase in French steel and pig iron production during March. There continues to be some activity in the electrical and mechanical engineering industries, but elsewhere the situation is unsatisfactory, without there being any indication of a possible improvement.

Engineers' Status.

The increasing number of private schools that swell the ranks of engineers with diplomas of more or less value has long been regarded as seriously affecting the status of the profession. There have been conferences and congresses in the hope of settling upon some method of granting diplomas which will offer a guarantee that holders possess the necessary qualifications, and an important meeting has just been held at the Société des Ingenieurs Civils, when reports were presented by the Federation of engineering associations, societies and syndicates, as well as by the State engineering institutions, universities and private schools. The idea has always been to close the ranks of the profession to those who do not possess recognised diplomas. The trouble is that the State institutions like the Ecole Polytechnique, Ecole Centrale and Arts et Métiers, are too exclusive, and the old students are grouped in powerful corporations which create a sort of caste in the profession. It is argued that any exclusive system must deprive the country of engineering talent, when everything should be done to bring out the best available; but Monsieur L. Guillet, director of the Ecole Centrale, was of the opinion that the training must necessarily be selective. The foundation of an engineer's qualifications, he said, should be sound moral character and a classical education, upon which should be based a good scientific, technical and practical instruction. Other speakers declared that natural gifts of invention and research should be encouraged and developed wherever possible. Moreover, the engineering profession is nowadays one of specialisation. The general conclusion arrived at was that, while preserving the present system so far as concerns the State institutions, private schools should not be allowed to issue diplomas, but that the State should organise examinations and grant two diplomas, one for general, technical and scientific knowledge, and the other for practical engineering work.

Railway Electrification.

Out of a total of 2636 miles constituting the Midi railway system, the electrified sections now at work have a length of 643 miles, and when the lines now in course of transformation are completed four years hence, the length of the electrified system will be 1150 miles. The work will then be continued until, in time, the whole of the railway will be electrified. There are at present in the Pyrenees, seven hydro-electric power stations producing annually about 500 million kWh. The Midi Railway Company does not intend to put down any further power installations itself. That will be left to the Société Hydro-Electrique du Midi, which has been formed by the railway company, as well as to several private enterprises which have obtained concessions and will eventually supply energy not only for the railway, but also for industrial purposes. Except on the Paris-Orleans railway, where the electrification is carried out actively, very little has been done elsewhere, except on the P.L.M. line between Culoz and Modane. There are plans, that may materialise in the distant future, to electrify the State line between Paris and Cherbourg in order to accelerate traffic on a difficult railway, but there is little chance of anything being done on the Nord and the Est, although in the latter case the construction of the Alsace Canal, with its supply of electrical energy, may raise the question of electrification some years hence. Nevertheless, there is no intention at present to employ electrical traction of railways serving the Eastern frontier. It is known that the directors of the Nord Railway Company are opposed to electrification. Running through a colliery district there is no advantage in superseding the present efficient steam locomotives.

Trade and Tariffs.

The proposed new scale of import duties into the United States is raising a far more serious protest over most of the Continent than has been experienced heretofore. Chambers of Commerce affirm that essentially French industries will be ruined by the exclusion of their products from the United States, and at a meeting of industrial representatives in Switzerland it was suggested that the situation could only be met by a boycott of American goods. While it is evident that American manufacturers are seeking to protect themselves from the lower production costs in Europe, it is equally clear that the effect of the new tariffs, if adopted in their present form, will be to strengthen the movement in favour of a European commercial union.

THE tonnage of coal exported from this country during the year 1929 was about 60¼ million tons, being an increase of 20 per cent. over 1928. Commenting thereon, Mr. Whitelaw said that the export from the North-East Coast ports, including the Humber ports, was 5¾ million tons.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

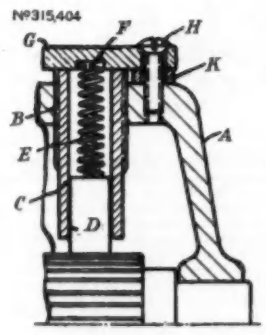
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

315,404. June 26th, 1929.—ELECTRIC MOTORS, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

It is frequently necessary that the outside diameter of electric motors should be kept as small as possible in order to reduce the space occupied by the machine. In small power motors such as are used, for instance, with vacuum cleaners, table fans, &c., in which the stator plates are held by a frame that, in addition to the bearings for the motor spindle, carries the brush holder, the diameter of the motor is increased in an undesirable manner by the closing caps or covers of the sleeves used for guiding the carbon brushes, as the closing caps made of insulating material project beyond the outer circumference of the motor and, therefore, render compact fitting of the motor difficult. This drawback is avoided according to the invention by making the closing cap or cover of the sleeve for guiding the brush in

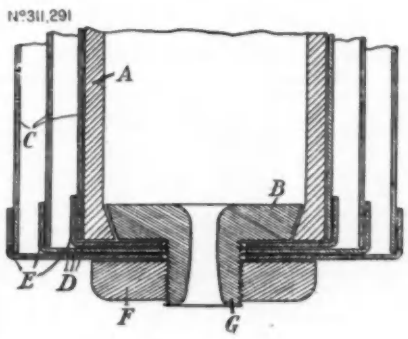


the form of a plate of small height which is screwed to the bearing frame of the motor. A is a frame of non-magnetic material which carries bearings for the motor spindle, as well as the stator plates of the motor, which are not shown. In a hole B of the frame is inserted an insulating sleeve C for guiding a carbon brush D which is pressed by a spring E against the commutator of the motor. The upper end of the spring engages in a recess F in a cover G of insulating material, and the cover is rigidly secured to the bearing frame A by a screw H. As the outer end of the insulating sleeve C projects beyond the bearing frame A, the cover G cannot lie close against the bearing frame A and an intermediate layer K of insulating material having a hole for a screw H is provided. When the carbon D is to be replaced, the screw H is slightly loosened and the cover G turned round, so that the carbon becomes accessible and can be easily removed.—*April 3rd*, 1930.

SWITCHGEAR.

311,291. May 8th, 1929.—ELECTRIC OIL SWITCHES, *International General Electric Company, Inc., of* 120, *Broadway, New York, United States of America.*

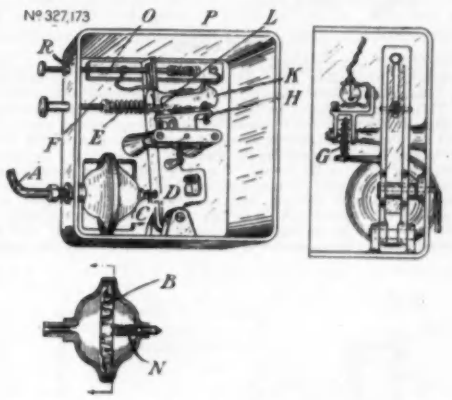
The practice of surrounding the explosion chambers of electric oil switches with insulating cylinders in order to increase the breakdown voltage between the explosion chambers and adjacent points at different potential is known. According to this invention, the effect of these cylinders is improved by arranging a series of discs of some insulating material perpendicularly to the axis of the explosion chamber, the discs being securely connected with the bottom of the explosion chamber and



having upturned rims which overlap the ends of the insulating cylinders. In the accompanying drawing A is the actual explosion chamber which may consist of metal and which is closed by a base B. The surrounding insulating cylinders are indicated at C. Below the base of the explosion chamber there are plates D of insulating material, the upturned edges E of which overlap the ends of the respective insulating cylinders. The plates are held against the bottom of the explosion chamber by means of the nut F, which may also consist of insulating material, and which is screwed on to the tube-like extension G at the base of the explosion chamber.—*March 27th*, 1930.

327,173. December 27th, 1928.—FLUID PRESSURE OPERATED ELECTRIC SWITCH, Marlo Refrigerating Company, Ltd., of No. 16, Spring-street, Sydney, and Frank Charles Malin, of No. 24, Gordon-street, Burwood, near Sydney.

The switch described in this specification has been devised to provide for automatically starting and stopping an electric motor, especially one operating to generate fluid pressure. The pressure fluid passing through the pipe A impinges on diaphragm B and forces the push-rod C against the lever D, the movement of which is governed by the tension of the spring E, which may be adjusted by screwing the tension rod F. When the arbitrary set pressure of fluid is reached the diaphragm movement pushes the pin, which forces the main lever D to such position that the spring G pulls the rocking cradle H to one side, so causing the mercury in the switch K to cover or uncover the contacts L which make or break the electric circuit and hence operate the motor controls. The actions are reversed when the springs N and E

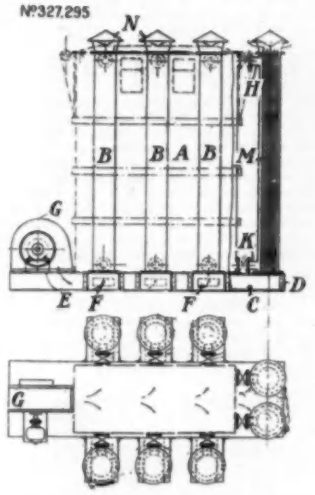


overcome the pressure of the fluid against the diaphragm B whenever the fluid pressure is reduced. The rod O with its buffer spring P provides an additional control of the lever D, and thus ensures a delicate adjustment of the switch to the fluid pressure as the position of the spring P relatively to the lever D can be adjusted by screwing the rod O in or out of the nut R.—*March 27th*, 1930.

TRANSFORMERS AND CONVERTERS.

327,295. April 12th, 1929.—TRANSFORMER TANKS, Edward Lloyd Pease, of Hurworth Moor, Darlington, Durham, and the Premier Radiator and Engineering Company, Ltd., of Skerne Works, Albert-hill, Darlington.

The tank A to which the radiators B are adapted to be attached —as, for instance, a transformer tank for an oil-cooled transformer—is supported on an underframe C, or trolley, to which plates D are secured in such manner as to form an air chamber or duct which is provided with an air inlet at E and with a number of air outlet openings or passages F. A fan G forces air into



the chamber or duct through the air inlet at E, and thence through the air outlet openings or passages F. Each radiator B comprises a casing of circular, square, rectangular or any other convenient shape in cross section, provided with upper and lower branches H and K respectively for attachment to the tank and closed at its upper and lower ends by plates or covers provided with a number of holes in which the upper and lower ends of a group of cooling tubes M are secured in a liquid-tight manner. If desired, as, for instance, when the tank is used outdoors, weather caps N with air deflectors may be arranged over the upper ends of the air tubes.—*April 3rd*, 1930.

TELEGRAPHS AND TELEPHONES.

306,393. January 30th, 1929.—SUBMARINE CABLES, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

In former times the individual cores of a marine cable were insulated by applying to the cores a relatively thick paper winding consisting of several layers. This was accompanied by the drawback that, relatively speaking, the capacity of the individual cores was high. In order to avoid this inconvenience there has been adopted the system of winding in spirals upon the bare conductor some such spacing medium as a cord upon which the core insulation is applied. In such cables, however,

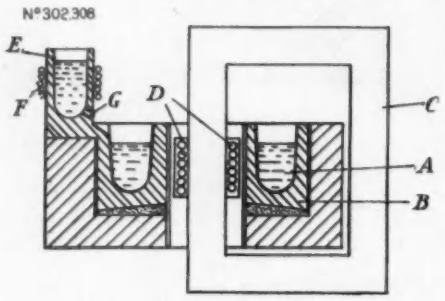
owing to the strong strain or stress which the cable experiences when being laid, and in the case of subsequent removal, there is the danger that strong local bending stresses will occur, owing to which the core insulation is spread apart, so that two adjacent conductors could come into contact at certain points. In order to obviate these drawbacks and, in particular, in order to keep moisture away from the copper conductor insulated on the paper-enclosed-air-space system, is has been proposed to apply enamel-lac to the bare conductors as a protection against the cores of the cable coming into contact. That, however, is accompanied by the drawback that the cores cannot be dried at a sufficiently high temperature because the enamel will

crack at the usual drying temperature of 100 deg. to 110 deg. The present invention has reference to a marine cable which does not possess the disadvantages common to cables coated with enamel. In the drawings a working example of the application of the invention is shown. A is the copper conductor, B a thin strip of paper wound upon the copper conductor, C is a round cord forming the air gap and D is the external insulating covering which consists of a strip of paper. Several such cores are combined to form the core of a cable.—*April 3rd*, 1930.

FURNACES.

302,308. November 27th, 1928.—INDUCTION SMELTING FURNACES, Johannes Hårdén, of Herserud, Sweden.

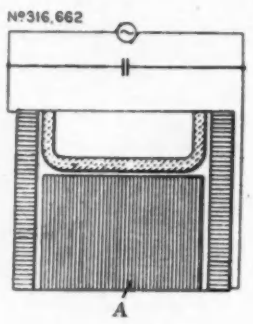
This invention consists in providing a combination furnace comprising a main low-frequency furnace with closed iron core and an auxiliary high-frequency furnace without a closed iron core, and the high-frequency furnace is connected to the low-frequency furnace by means of a duct, so that a preliminary starting charge may be melted in the high-frequency furnace and then transferred directly to the low-frequency furnace for starting the latter. A indicates the low-frequency casting gutter, which is embedded in insulating material B and is surrounded by the iron core C. D is the primary coil. The high-



frequency furnace E with a coil F is situated above the casting gutter, and a duct G is provided by means of which the melted starting charge may be conveyed to the casting gutter A. This duct is conveniently kept closed during the melting of the starting charge. The low-frequency furnace is supplied with a single or multi-phase current of low frequency, and the high-frequency furnace is fed by a high or medium-high frequency of, for example, about 200 cycles. Advantageously, the high-frequency furnace is supplied from the same current supply as the low-frequency furnace, a suitable frequency transforming device, such as a rotary converter, arc generator, or the like, being provided for converting the low-frequency into a higher frequency.—*March 27th*, 1930.

316,662. July 9th, 1929.—ELECTRIC FURNACES OF THE INDUCTOR TYPE, Edwin Fitch Northrup, of Ajax Park, Trenton, New Jersey.

In induction furnaces a considerable amount of heat is dissipated owing to the resistance of the inductor coil. This may be reduced for a given number of ampère-turns by enlarging the cross section of the turns, and since the current is largely concentrated at the inner portion of the inductor, this enlargement must be in the direction parallel to the axis, thereby increasing the axial length of each turn and of the whole coil. For various reasons, however, such as the difficulty in handling a furnace of great height, it is found that it is desirable that the length of the coil should be approximately equal to its diameter. It is also advisable to treat the metal in a shallow furnace, which

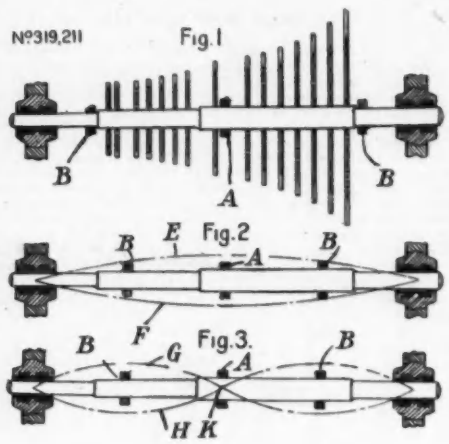


in some cases may have a diameter greater than its axial length. The coil has usually been formed as a narrow band surrounding the charge, since an extension of the coil below the charge would in the previously known constructions involve the inclusion within the magnetic circuit of an air gap of such length, that the reluctance would more than counterbalance the advantage gained by the extension of the coil. According to the invention, the drawback owing to the increased length of the coil is obviated by the insertion of a core A of magnetic material within the portion of the extension unoccupied by the charge and the hearth or base of the crucible. In this way, in the case of an extended coil, the air gap traversed by the magnetic flux is only slightly more than with a short inductor coil—*April 3rd*, 1930.

MISCELLANEOUS

319,211. September 16th, 1929.—METHODS OF AND MEANS FOR BALANCING ROTORS, the British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C. 2.

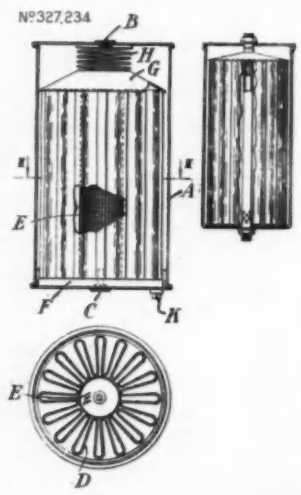
According to this invention, a rotor is balanced for the first critical speed by means of a weight arranged in the vicinity of the nodal point of the rotor at second critical speed and the rotor is balanced for running speed by means of weights arranged in the vicinity of the ends of the rotor. By this means the result is obtained that the weight used for balancing for the first critical speed has little effect on the balance so far as the second critical speed is concerned and the weights which are used for balancing at running speed take care of vibration which may be due to the second critical speed without materially affecting the balance of the rotor for first critical speed. A indicates a balancing ring placed in the vicinity of the nodal point of the rotor at the second critical speed for adding weights to balance the rotor at the first critical speed, and B indicates balancing rings placed in the vicinity of the bearings and utilised for balancing the rotor at running speed by the addition of weights. The balancing rings are provided with spaced tapped holes for the reception of suitable balancing weights. Referring to Fig. 2, the nature of the vibration of the shaft at the first critical speed is indicated in exaggerated form by the lines E and F. At the first critical speed all the fibres on the same side of the shaft are bowed in the same direction and the shaft, slightly bowed, whirls about its geometrical axis. This whirling action sets up movements which can be measured at the bearings as vibrations. It will be clear that by adjusting the balancing weight or weights in the ring A the rotor can be balanced for this speed. Referring now to Fig. 3, the nature of the vibrations of the shaft at the second critical speed is indicated in exaggerated form by the lines G and H. At second critical speed the shaft whirls in two sections, there being a nodal point at about the central point of the shaft, as is indicated at K. With the balancing ring A placed at the point K it will be clear that adjustment of the weight or weights in ring A will have little effect so far as balance at second critical speed is concerned. On the other hand, the weights in the



balancing rings B which are shown as being in the vicinity of the bearings may be adjusted for balance at second critical speed, and since they are in the vicinity of the bearings, will have little effect on the balance at first critical speed. On successive adjustments of the weights in balancing rings A and B, it is possible to reduce the amplitude of vibrations to within allowable limits at first critical speed and at running speed. By this arrangement, therefore, wherein the rotor is balanced for first critical speed by means of a weight arranged in the vicinity of the nodal point of the second critical speed, and balance at the running speed by means of weights in the vicinity of the bearings, it is possible to obtain a better balance at both the first critical speed and at the running speed, than is possible by the elimination of the balancing ring at the nodal point of the shaft at second critical speed.—*April 3rd*, 1930.

327,234. February 7th, 1929.—OIL FILTERS, Cecil Gordon Vokes, of 95, Lower Richmond-road, Putney.

This invention relates to oil filters for use more particularly in connection with internal combustion engines. A cylindrical container A is provided with upper and lower inlet and outlet passages B and C. Within the container is a filtering wall D of felt, folded to a star shape. The inner points of the star are secured by stitches or staples to an inner tube E of wire gauze.



The filtering wall rests on a washer F, which may be formed of the same kind of material and above it is a deflector cone G held down by a light spring H. Oil entering the tube B is deflected by the cone G outwardly of the star-shaped deformation of the felt, and then passes through the felt and out through the discharge pipe C. During its passage through the felt it is filtered and any sludge collecting in the bottom of the container may be removed from time to time through a drain plug K.—*April 3rd*, 1930.

327,223. January 24th, 1929.—INSULATION OF ELECTRIC CONDUCTORS, *Siemens Brothers and Co., Ltd., of Carton House, Tothill-street, London, S.W. 1.*

In the manufacture of paper insulated cables, the usual practice is to apply dry paper wrapping to the core and then dry the cores in a vacuum, subsequently impregnating the cores with a suitable insulating oil or compound. In the vacuum drying, air entrapped between the layers of wrapping is removed as far as possible, and it is very desirable that it should be done at this stage, as after impregnation it is difficult to remove entrapped air as may be established by tests. Difficulty is found, therefore, in removing air in the case of a cable joint when all the appliances available in a factory are not available on site and the paper is impregnated before application to the joint. The invention has in view means facilitating the removal of air entrapped between layers of impregnated paper applied to conductors, and such means are highly advantageous in respect of joints, as by their use wide wrappings may be used, thereby lessening the time required to insulate the joint. According to the invention the paper used to insulate the conductor is perforated so that air may pass readily from the interior of the insulation to the outside. Further, the pressure within the cable due to the expansion of the impregnating compound with the heating of the cable may be equalised in a radial direction. By the provision of holes suitably spaced as regards the breadth of a wrapping, the actual breadth is of no importance as far as the passage of air and compound from one layer to another is concerned. The holes as regards the length of the wrapping may be in line or successive rows of holes may be displaced relatively to each other. The distance apart of the rows of perforations along the length of the wrapping is suited to the conductor diameter, the intention being that there should be at least one row per complete turn. A suitable size hole is one of $\frac{1}{16}$in. in diameter. The invention may be applied to joints wrapped with a tapered wrapping of impregnated paper or other fibrous material in which the greatest breadth of the wrapping approximates to the length of the core exposed, and also to helically applied wrapping, in which case a wider wrapping than is permissible without perforations may be used. Whilst the invention is specially applicable to the making of joints using paper already impregnated, it is also applicable to the insulation of cables in the manufacture of which paper impregnated before application to the conductor is employed.—*April 3rd*, 1930.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

CHEMICAL ENGINEERING GROUP.—At the Criterion Restaurant, Piccadilly-circus, London, W. 1. 6.45 p.m., annual meeting; 7.30 p.m., annual dinner; morning dress. After the dinner an informal discussion will take place on "The International Abstracting and Classifying of Scientific Literature," introduced by Sir Frederic L. Nathan. The President, Dr. Herbert Levinstein, is expected to speak on "Chemistry House—the Present Position." The General Secretary will deal with "The Jubilee Meeting of the Society."

TUESDAY, MAY 13TH.

INSTITUTE OF MARINE ENGINEERS.—The Minories, London, E.C. 3. "Developments in Powdered Fuel Practice for Marine Service," by Mr. E. W. Green. 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, S.W. 1. Annual general meeting. 6 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.—Queen's Chambers, 5, John Dalton-street, Manchester. Ordinary meeting, 4 p.m. The Council will meet at 3 p.m.

WEDNESDAY, MAY 14TH.

INSTITUTE OF FUEL.—In the Rooms of the Chemical Society, Burlington House, Piccadilly, W. 1. "The Utilisation of Town's Gas as a Fuel in Heat Treatment Furnaces," by Dr. C. M. Walter. 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS: YORKSHIRE BRANCH.—Whole-day visit to Hope Cement Works.

THURSDAY, MAY 15TH.

INSTITUTION OF ELECTRICAL ENGINEERS.—In the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. Annual general meeting. 6 p.m.

FRIDAY, MAY 16TH.

INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—In the Hall of the Technical College, Bell-street, Dundee. The Twenty-first Kelvin Lecture, entitled "Some Recent Advances in the Electron Theory of Metals," by Mr. R. H. Fowler, F.R.S. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, W. 1. Discourse, "The Great Barrier Reef of Australia," by Mr. C. M. Yonge. 9 p.m.

THE INSTITUTE OF TRANSPORT.—The Institute of Transport announces that the Council has elected the undernamed to take office at October 1st, 1930:—President, The Hon. Sir Arthur Stanley. Past-presidents to serve on the Council: Sir Henry P. Maybury, Colonel Sir Joseph Nall, D.S.O., T.D., R. H. Selbie, Roger T. Smith, Air Vice-Marshal Sir W. Sefton Brancker, and Sir Josiah C. Stamp. Vice-presidents: A. L. Barber, R. Bell, Sidney E. Garcke, R. J. Howley, J. H. Follows, and D. J. Owen. Honorary treasurer: Sir Henry P. Maybury.

THE ROYAL SANITARY INSTITUTE.—This year's Congress of the Royal Sanitary Institute—the 41st—will be held at Margate from June 21st to 28th next under the presidency of The Right Hon. Lord Cornwallis, who is chairman of the Kent County Council. Among the many subjects which are to be discussed are:—"The Estimation of the Rat Population in Ships"; "Crew Accommodation in Ships," "Cold Storage," "Sanitary Plumbing, Building and Sanitary By-Laws," "Rating of Sewers and its Effect on Sanitation," "Regional Control of Sewage Purification Works," "The Margate Water Undertaking," "The Promenades and Sewerage of Margate," "The Roads in Kent." A Health Exhibition is to be held at Hartsdown during the continuance of the Congress. It is expected that, including delegates, Members of the Institute, officers of the Congress, visitors and others, the total attendance at the meeting will be about 1500. Among the Foreign and Dominion Governments, &c., to be represented will be:—The Commonwealth of Australia, South Australia, New South Wales, Victoria, The Punjab, Bombay Municipality, Karachi Municipality, the United Provinces (India), Capetown, the United States, Port Elizabeth, Pretoria, Lagos, Ontario, Nova Scotia, Singapore, Egypt, Denmark, Greece, Luxembourg, Mexico, Persia, Poland and Bordeaux.

ROYAL INSTITUTION.—The Annual Meeting of the Members of the Royal Institution was held on May 1st, Sir Robert Robertson, Treasurer and Vice-president, in the chair. The annual report of the Committee of Visitors for the year 1929, testifying to the continued prosperity and efficient management of the Institution, was read and adopted. The report of the Davy Faraday Research Laboratory Committee was also read. Fifty new Members were elected during the year. Thanks were voted to the President, Treasurer and Secretary, to the Committees of Managers and Visitors, and to the Professors, for their valuable services to the Institution during the past year. The following were unanimously elected as officers for the ensuing year:—President, The Duke of Northumberland; Treasurer, Sir Robert Robertson; Secretary, Major C. E. S. Phillips; managers, A. Chaston Chapman, Ernest Clarke, Sir James Crichton-Browne, W. H. Eccles, W. Vaux Graham, Sir Herbert Jackson, Sir Lawrence Jones, V. Warren Low, Colonel Sir Henry Lyons, Sir Henry Miers, Hon. Sir Charles Parsons, Clifford C. Paterson, Robert W. Paul, Lord Rayleigh and W. J. Tennant; visitors, Colonel N. T. Belaiew, Frederick H. Berryman, C. V. Drysdale, Montague Ellis, G. E. Gask, David Heron, G. W. C. Kaye, Percy J. Neate, A. O. Rankine, E. H. Rayner, Hugh Munro Ross, T. C. Sandeman, Harold R. D. Spitta, Alfred E. Western and Robert S. Whipple.